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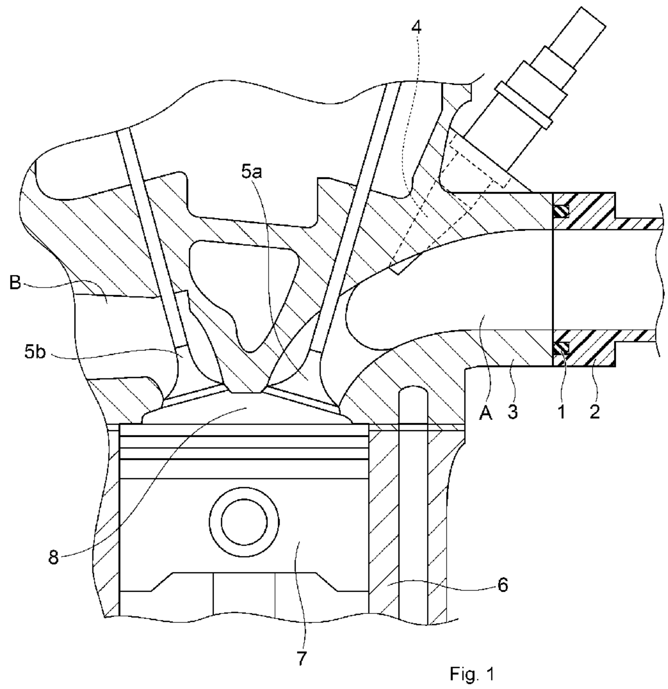

Fig. 1

(57) **Abstract:** Provided are a seal part for an engine intake system which has durability even under an environment including a polycyclic aromatic component, while hydrogenated nitrile rubber having fuel resistance and heat resistance is used, and a seal structure of the engine intake system. The seal part for an engine intake system is suitable for use in a seal (member denoted with reference sign (1) of a direct coupling portion between an engine cylinder head (3) and an intake manifold (2), and includes hydrogenated nitrile rubber in which a combined acrylonitrile amount is in a range of 15% to 20.5% by mass and a hydrogenation rate is 93% or more, and an inorganic filler having an amount of at least 125 parts by mass or more to be blended with 100 parts by mass of polymer content, wherein hardness is adjusted in a range of 63 to 77 degrees, and a seal structure of the engine intake system in which the seal part is used.

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[Continued on next page]

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SEAL PART FOR ENGINE INTAKE SYSTEM AND SEAL STRUCTURE OF ENGINE INTAKE SYSTEM

BACKGROUND OF THE DISCLOSURE

Field of the Disclosure

[0001]

The present disclosure relates to a seal part for an engine intake system, and a seal structure of the engine intake system.

Description of the Related Art

[0002]

Heretofore, hydrogenated nitrile rubber has been used in a seal part for an engine intake system from viewpoints of fuel resistance (oil resistance) and heat resistance.

On the other hand, due to direct injection of fuel, complication of valve timing and the like accompanying requests for improvement of fuel efficiency, there is tendency that an amount of blowback fuel blown back from a combustion chamber back to the intake system increases.

[0003]

In this blowback fuel, a polycyclic aromatic component secondarily generated in the combustion chamber is mixed, and the polycyclic aromatic component adheres to and is impregnated in the seal part made of hydrogenated nitrile rubber. The polycyclic aromatic component acts as a nucleating agent of crystallization of the hydrogenated nitrile rubber itself in the hydrogenated nitrile rubber, to crystallize and harden the rubber. As a result, the compressed seal part made of the hydrogenated nitrile rubber loses rubber elasticity and causes trouble to a seal function.

[0004]

To improve this situation, it is common to use fluororubber or fluorosilicone rubber that is not affected by the polycyclic aromatic component as a material of the seal part, but cost significantly increases as compared with a case where the hydrogenated nitrile rubber is used.

[0005]

Furthermore, in International Publication No. WO2013/175878, disclosed is a polyamine vulcanizable, highly saturated nitrile rubber composition having an excellent cold resistance after immersed into polycyclic aromatic compound-containing fuel oil, and comprising 100 parts by mass of polyamine vulcanizable, highly saturated nitrile rubber including an α, β-ethylenically unsaturated nitrile monomer unit, a diene-based monomer unit, an α, β-ethylenically unsaturated dicarboxylic acid monoester monomer unit and an α, β-ethylenically unsaturated carboxylic acid ester monomer unit other than the α, β-ethylenically unsaturated dicarboxylic acid monoester monomer unit, having an α, β-ethylenically unsaturated nitrile monomer unit content of 21.0 to 23.0 wt% and having an iodine value of 120 or less, and blended with 4 to 31 parts by mass of an aliphatic carboxylic acid diester compound of polyalkylene glycol. However, with the present composition, in the blowback fuel including a larger amount of polycyclic aromatic component, an effect of improvement of low temperature seal properties is low and is not sufficient.

[0006]

In particular, a seal of a direct coupling portion between an engine cylinder head and an intake manifold has a short distance from the engine combustion chamber, and is easily exposed to the blowback fuel having a larger content of polycyclic aromatic component. Consequently, a seal structure having a resistance as high as possible to the polycyclic aromatic component is desired.

[0007]

Therefore, the present disclosure is related to providing a seal part for an engine intake system which has durability even under an environment including a polycyclic aromatic component, while hydrogenated nitrile rubber having fuel resistance and heat resistance is used.

Furthermore, the present disclosure is related to providing a seal structure of an engine intake system having a resistance as high as possible to a polycyclic aromatic component.

SUMMARY OF THE DISCLOSURE

[0008]

To solve such a situation as described above, according to an aspect of the present disclosure related to a seal part for an engine intake system,

provided is a seal part for an engine intake system, comprising hydrogenated nitrile rubber in which a combined acrylonitrile amount is in a range of 15% to 20.5% by mass and a hydrogenation rate is 93% or more, and an inorganic filler having an amount of at least 125 parts by mass or more to be blended with 100 parts by mass of polymer content,

in which hardness is adjusted in a range of 63 to 77 degrees.

[0009]

According to the above described aspect of the present disclosure related to the seal part for the engine intake system, the combined acrylonitrile amount that is easily affected by a polycyclic aromatic component is significantly decreased. While inhibiting crystallization by the polycyclic aromatic component, it is possible to achieve another performance such as heat resistance, fuel resistance or durability. Consequently, the seal part for the engine intake system can have a higher resistance to the polycyclic aromatic component.

[0010]

In another aspect of the present disclosure, it is desirable to be subjected to peroxide vulcanization or amine vulcanization. According to the seal part for the engine intake system obtained by such a vulcanization method, a resistance to compression set, that is, a creep property (a permanent set resistance) can improve.

[0011]

In still another aspect of the present disclosure, it is preferable that the nitrile rubber in which the combined acrylonitrile amount is 20% or more by mass is blended with hydrogenated nitrile rubber within 30 mass%. A nitrile rubber component that is hard to be affected by the polycyclic aromatic component and that is not hydrogenated is mixed within a range in which an effect on the heat resistance is hard to occur, so that a resistance to the polycyclic aromatic component can further improve.

[0012]

The seal part for the engine intake system according to a further aspect of the present disclosure can be suitably used in a seal of a direct coupling portion between an engine cylinder head and an intake manifold. This corresponding region is easily exposed to blowback fuel containing the polycyclic aromatic component, and hence, by use of the seal part for the engine intake system according to the aspect of the present disclosure which has a high resistance to the polycyclic aromatic component, durability improves.

[0013]

On the other hand, according to an aspect of the present disclosure related to a seal structure of an engine intake system,

provided is a seal structure of a direct coupling portion between an engine cylinder head and an intake manifold, in which:

the intake manifold includes a seal mounting groove,

the seal part for the engine intake system according to the aspect of the present disclosure is mounted in the seal mounting groove in a partially projected state, and an end in the projected state is pressed by a surface that forms the direct coupling portion of the cylinder head to the intake manifold,

in a cross section of the seal mounting groove, the seal part for the engine intake system is in contact with opposite side surfaces of the seal mounting groove, and a ratio (y/x) of a presence area (y) of a cross section of the seal part for the engine intake system to a cross sectional area (x) of a rectangular seal space (hereinafter referred to also as "the rectangular seal space") surrounded with the cylinder head, the seal mounting groove and extensions of the opposite side surfaces of the groove is in a range of 0.75 to 0.90.

[0014]

According to the aspect of the present disclosure related to the above seal structure of the engine intake system, the ratio of the presence area of the seal part for the engine intake system to an area of the rectangular seal space in the direct coupling portion between the engine cylinder head and the intake manifold (hereinafter referred to also as "a filling ratio") is set to be as high as possible while acquiring allowance. Consequently, a proper sealability can be acquired while inhibiting compressive deformation of the seal part for the engine intake system.

[0015]

In the seal structure of the engine intake system according to another aspect of the present disclosure, it is preferable that the intake manifold is made of a resin.

Since the intake manifold is made of the resin, a complicated seal groove shape and layout can be precisely manufactured in one forming process for a short period of time. Consequently, as a result, a high sealability can be acquired at low cost.

[0016]

As above, according to a seal part for an engine intake system of the present disclosure, the seal part can have a higher resistance to a polycyclic aromatic component.

Furthermore, according to a seal structure of the engine intake system of the present disclosure, the resistance to the polycyclic aromatic component can be as high as possible.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIG. 1 is a partially cross-sectional view of a vicinity of an engine cylinder head, showing a state where a seal part for an engine intake system of an embodiment according to the present disclosure is applied to a seal of a direct coupling portion between the cylinder head and an intake manifold;

FIG. 2 is an enlarged cross-sectional view of the direct coupling portion between the cylinder head and the intake manifold;

FIG. 3 is a further enlarged cross-sectional view of a vicinity of the seal part for the engine intake system in the direct coupling portion of FIG. 2;

FIG. 4 is an enlarged cross-sectional view of the seal part for the engine intake system manufactured in an example; and

FIG. 5 is a schematic cross-sectional view showing a use state of a jig made of aluminum and used in an evaluation test in the example.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018]

Hereinafter, a seal part for an engine intake system of the present disclosure will be first described in detail. In description of a use application of the seal part, a preferred embodiment of a seal structure of the engine intake system of the present disclosure will be described.

[0019]

[Blend Component]

A seal part for an engine intake system of the present disclosure (hereinafter also referred to simply as "the seal part of the present disclosure") includes hydrogenated nitrile rubber that is a polymer and an inorganic filler as essential components, and includes another component in accordance with a purpose or a request.

[0020]

<Polymer>

The seal part of the present disclosure includes hydrogenated nitrile rubber as a main component polymer, and in particular, includes hydrogenated nitrile rubber as a main component in which a combined acrylonitrile amount is in a range of 15% to 20.5% by mass and a hydrogenation rate is 93% or more.

[0021]

In the seal part of the present disclosure, the combined acrylonitrile amount of the hydrogenated nitrile rubber for use is in the range of 15% to 20.5% by mass, and preferably in a range of 15% to 18%. If the combined acrylonitrile amount is excessively large, a resistance to a polycyclic aromatic component easily becomes insufficient, and if the combined acrylonitrile amount is excessively small, there is concern that a basic performance of the seal part having fuel resistance or the like is insufficient.

[0022]

The hydrogenation rate of the hydrogenated nitrile rubber for use is 93% or more, and preferably 95% or more. Increase of the hydrogenation rate can improve fuel resistance and heat resistance of the engine intake system. Note that as the hydrogenated nitrile rubber in which the combined acrylonitrile amount is in the range of 15% to 20.5% by mass and the hydrogenation rate is 93% or more, a single structure may be used, and a plurality of types of structures may be for combined use.

[0023]

With the polymer, nitrile rubber that is not hydrogenated (hereinafter, when simply referring to "nitrile rubber", the nitrile rubber that is not hydrogenated is indicated) may be for combined use. By the combined use of the nitrile rubber that is not easily affected by the polycyclic aromatic component, an effect of improving the resistance to the polycyclic aromatic component can be expected.

[0024]

As the nitrile rubber for use at this time, the combined acrylonitrile amount is preferably 20 mass% or more, and more preferably 25 mass% or more and 42 mass% or less. If the combined acrylonitrile amount in the nitrile rubber for use is excessively small, the fuel resistance may be insufficient, and if the amount is excessively large, there is concern that deterioration of a low temperature resistance and deterioration of mechanical properties due to poor dispersion in the hydrogenated nitrile rubber are caused.

[0025]

Furthermore, an amount of the nitrile rubber to be blended for combined use is preferably within 30 mass% to the hydrogenated nitrile rubber, and more preferably 15 mass% or more and 30 mass% or less. If the amount of the nitrile rubber to be blended is excessively large, the fuel resistance and heat resistance may be insufficient, and if the amount is excessively small, an effect of improving the resistance to the polycyclic aromatic component by the combined use cannot be expected.

[0026]

In the present disclosure, as a polymer other than the hydrogenated nitrile rubber and nitrile rubber, another polymer may be mixed in such a range that does not impair a function of the seal part of the present disclosure. Examples of the mixable polymer include vinyl chloride resin, ethylene propylene rubber, ethylene propylene diene rubber, fluororubber, chloroprene rubber, epichlor, hydrin rubber, and acrylic rubber.

[0027]

<Inorganic Filler>

The seal part of the present disclosure is blended with the inorganic filler. Here, "the inorganic filler" refers to an inorganic solid that is blended in the rubber component to increase in amount and that hardly has a chemical effect (excluding a mere electrostatic effect) on the rubber component.

[0028]

Suitable examples of the inorganic filler for use in the present disclosure can include carbon black, silica, calcium carbonate, kaolin, talc, mica, wollastonite, montmorillonite, sericite, wax stone, and alumina. Among these examples, carbon black, silica, calcium carbonate, and kaolin are especially preferable.

[0029]

An amount of the inorganic filler to be blended with 100 parts by mass of polymer content is 125 parts by mass or more, preferably in a range of 125 parts by mass or more and 200 parts by mass or less, and more preferably in a range of 135 parts by mass or more and 190 parts by mass or less. If a predetermined amount or more of the inorganic filler is blended, it is possible to inhibit the effect of the polycyclic aromatic component and to improve the resistance. On the other hand, if a blend ratio of the inorganic filler is excessively large, an appropriate hardness, flexibility, and compression set of a seal material are hard to acquire.

[0030]

<Other Components>

The seal part of the present disclosure can be blended with other components such as respective known types of additives, in addition to the above described essential and main components. Examples of the other components that are blendable include a heretofore known plasticizer, an anti-aging agent, a processing aid, an acid acceptor, a coupling agent, and a pigment.

[0031]

Furthermore, to vulcanize the hydrogenated nitrile rubber and nitrile rubber, a vulcanizing agent or vulcanization accelerator can be added. In the present disclosure, in the vulcanization of the hydrogenated nitrile rubber and nitrile rubber, it is preferable to perform peroxide vulcanization or amine vulcanization. In usual vulcanization with sulfur, there is concern that problem occurs in a resistance to compression set, that is, a creep property (a permanent set resistance), but such a situation can be improved by performing the peroxide vulcanization or amine vulcanization.

[0032]

Examples of the vulcanizing agent in performing the peroxide vulcanization can include dicumyl peroxide, di-t-butyl peroxide, benzoyl peroxide, t-butyl peroxide benzoate, 2, 5-dimethyl-2, 5-di(t-butylperoxy)hexane, 2, 5-dimethyl-2, 5-di(t-butylperoxy)-hexine-3, and α, α'-bis(t-butylperoxy)-p-diisopropyl benzene. Furthermore, examples of the vulcanization accelerator in performing the peroxide vulcanization include ethylene glycol dimethacrylate (EDMA), trimethylolpropane trimethacrylate (TMPT), triallyl cyanurate (TAC), and triallyl isocyanurate (TAIC).

[0033]

Examples of the vulcanizing agent in performing the amine vulcanization can include polyamines such as hexamethylenediamine, hexamethylenediamine carbamate, and hexamethylene benzoate. Furthermore, examples of the vulcanization accelerator in performing the amine vulcanization can include basic vulcanization accelerators such as 1, 8-diazabicyclo [5, 4, 0] undesen 7 (DBU), and 1, 5-diazabicyclo [4, 3, 0] nonen 5 (DBN).

[0034]

[Hardness]

The seal part of the present disclosure is manufactured by the above blending, and additionally, hardness after the manufacturing is adjusted in a range of 63 to 77 degrees. The hardness is preferably adjusted in a range of 65 to 75 degrees, and more preferably adjusted in a range of 67 to 73 degrees. The hardness is adjusted in the appropriate range, so that flexibility of the seal part can be acquired, and creep during use for a long period of time can be inhibited. The seal part combined with practicality can be obtained.

Note that "the hardness" mentioned here is hardness prescribed in JIS K6253-3 "Vulcanized Rubber and Thermoplastic Rubber-Method of obtaining Hardness-Part 3: Durometer Hardness".

[0035]

Examples of a method of adjusting the hardness of the manufactured seal part of the present disclosure can include a method of appropriately selecting a ratio or type of each type of blend component (especially, the inorganic filler or the plasticizer) to adjust the hardness, and a method of appropriately selecting the ratio or type of the vulcanizing agent or vulcanization accelerator to adjust a crosslink density, and the present disclosure is not limited to these examples.

[0036]

[Manufacturing Method]

The seal part of the present disclosure can be manufactured as follows. That is, the above components excluding the vulcanizing agent and vulcanization accelerator are mixed, and A-kneaded compound is prepared with a kneading machine such as a kneader or Banbury mixer. Thereafter, the vulcanizing agent (further the vulcanization accelerator if required) is added, and B-kneading is performed, to finish a kneaded dough. The resulting kneaded dough is placed in a seal-shaped mold, and press molding vulcanization, injection forming vulcanization, or extrusion and then forming in an electric furnace or steam vulcanization may be performed.

Furthermore, it is preferable to further perform secondary vulcanization, thereby stabilizing the crosslink density (state).

[0037]

[Use Application of Seal Part for Engine Intake System of the present Disclosure]

The seal part of the present disclosure is a seal part for use in the engine intake system. In particular, it is preferable to use the seal part in a seal of a direct coupling portion between an engine cylinder head and an intake manifold.

[0038]

FIG. 1 is a partially cross-sectional view of a vicinity of the cylinder head of an engine, showing a state where the seal part of the embodiment according to the present disclosure is applied to the seal of the direct coupling portion between the cylinder head and the intake manifold. Each cylinder 6 of the engine includes a piston 7 therein. As the piston 7 rises and lowers, a mixed gas of fuel and air in a combustion chamber 8 is taken inside, compressed, expanded and discharged.

[0039]

Note that in the following example, a four-stroke (four cycle) engine using gasoline as fuel will be illustrated, but the seal part of the embodiment according to the present disclosure is applicable to both a two-stroke (two cycle) engine and a diesel engine that does not include an ignition plug without any problems.

[0040]

A cylinder head 3 is provided above the cylinder 6. In the cylinder head 3, intake and exhaust paths A and B are provided, and the intake path A and exhaust path B are brought into a sealed state by an intake valve 5a and an exhaust valve 5b, respectively, in principle. The intake path A communicates with an intake manifold 2, and a fuel injection device 4 is provided in a middle.

[0041]

Outside air is sent from the intake manifold 2 to the cylinder head 3, and fuel is injected to and mixed with the air with the fuel injection device 4 to generate a mixed gas. The generated mixed gas is supplied into the combustion chamber 8 through the intake valve 5a that is projected to the combustion chamber 8 and opened. At this time, the piston 7 lowers from an upper end toward a lower end, and operates to take the mixed gas into the combustion chamber 8 (an intake stroke).

[0042]

When the intake of the fuel ends, the intake valve 5a closes, and the piston 7 reverses and rises to compress the mixed gas in the combustion chamber 8 (a compression stroke). At end of a compression step, that is, when, before, or after the piston 7 reaches the upper end, the mixed gas in the combustion chamber 8 is ignited with an unshown ignition plug, and the mixed gas explodes. Then, with an explosive expansion force of the mixed gas in this case, an interior of the combustion chamber 8 expands, and the piston 7 is pushed down (an expansion stroke).

[0043]

When the piston 7 reaches the lower end, the exhaust valve 5b has the projected state to the combustion chamber 8 and is opened. As the piston 7 rises, the combusted mixed gas (a combustion gas) in the combustion chamber 8 is pushed out to the exhaust path B (an exhaust stroke). When the piston 7 reaches the upper end and the combustion gas in the combustion chamber 8 is pushed outside, the exhaust valve 5b closes, to proceed to a subsequent cycle that starts with the intake stroke.

[0044]

In the exhaust stroke, the combustion gas remaining in the combustion chamber 8 includes an incomplete combustion component. When the intake valve 5a opens immediately after start of the intake stroke, this incomplete combustion component is blown back to the intake path A depending on various structures and driving conditions. This component is referred to as "the blowback fuel". This blowback fuel is mixed with the polycyclic aromatic component secondarily generated in the combustion chamber.

[0045]

The blowback fuel may reach the direct coupling portion between the cylinder head 3 and the intake manifold 2. A seal part 1 according to the present embodiment (a seal part for an engine intake system) is suitably for use in a seal of this direct coupling portion (an embodiment of a seal structure of the engine intake system according to the present disclosure).

[0046]

FIG. 2 shows an enlarged cross-sectional view of the direct coupling portion between the cylinder head 3 and the intake manifold 2. Around a tip opening of the intake manifold 2, a seal mounting groove 21 having the opening of the groove directed to the cylinder head 3 is formed to surround the tip opening. In the seal mounting groove 21, the annular seal part 1 partially projected from the opening of the groove is fitted. Furthermore, the projected seal part 1 is pressed by a surface that forms the direct coupling portion in the cylinder head 3 that is a counterpart member, and the direct coupling portion between the cylinder head 3 and the intake manifold 2 is sealed.

[0047]

FIG. 3 shows a further enlarged cross-sectional view of a vicinity of the seal part 1. A behavior is depicted in which the annular seal part 1 having an elliptic cross section is mounted in the seal mounting groove 21 provided to surround the tip opening of the intake manifold 2. At this time, the seal part 1 has an end projected from the seal mounting groove 21 and pressed with the above surface of the cylinder head 3.

Furthermore, in a cross section of the seal mounting groove 21, the seal part 1 is in contact with opposite side surfaces 22 of the seal mounting groove 21.

[0048]

At this time, a ratio (a filling ratio = y/x) of a presence area of the cross section (y) of the seal part 1 to a cross section (x) of a rectangular seal space 11 surrounded with the cylinder head 3, the seal mounting groove 21 and extensions of the opposite side surfaces 22 of the groove (a broken line between the cylinder head 3 and the intake manifold 2) is preferably in a range of 0.75 to 0.90, and more preferably in a range of 0.78 to 0.87. The filling ratio is set to the appropriate range, so that a proper sealability can be acquired while inhibiting compressive deformation of the seal part 1.

[0049]

In general, the cylinder head 3 of the engine is manufactured by casting of aluminum or iron from quality requirements for heat resistance, rigidity dimension accuracy and the like. On the other hand, since the intake manifold 2 is a part of the intake system, the heat resistance and rigidity as high as those of the cylinder head 3 are not required. Consequently, in recent years, the manifold made of a resin has been increasingly adopted. The intake manifold 2 made of the resin has a high manufacturability, also contributes to weight reduction of the engine, also enables complicated seal groove design, and can acquire a high sealability at low cost. Examples of the specific resin usable in the intake manifold 2 can include polyamide 66, polyamide 6, aromatic polyamide, and polypropylene. Also in a case where any resin is used, it is preferable that the resin is reinforced with glass fibers or carbon fibers, to improve a mechanical strength.

[0050]

As above, the preferred embodiments of the seal part for the engine intake system of the present disclosure and the seal structure of the engine intake system have been described, but the seal part for the engine intake system of the present disclosure and the seal structure of the engine intake system are not limited to configurations of the above embodiments.

For example, in the above embodiment, an example where the cross sectional shape of the seal part is elliptic has been described, but the present disclosure is not limited to this example, and seal parts having various types of cross sectional shapes can be applied. For example, there are not any problems also with a seal part 10 of a cross sectional shape shown in FIG. 4 and manufactured for a test in an example described later. A seal part having a cross section of any other shape can be adopted, and there are not any problems with the shape as long as the sealability can be acquired. A seal part of a shape having an excellent sealability can be suitably adopted.

[0051]

Additionally, a person skilled in the art can follow heretofore known findings and appropriately modify the seal part for the engine intake system of the present disclosure and the seal structure of the engine intake system. Needless to say, such modifications are included in category of the present disclosure as long as the configurations of the seal part for the engine intake system of the present disclosure and the seal structure of the engine intake system are provided.

[Examples]

[0052]

Hereinafter, examples of the present disclosure will be more specifically described, but the present disclosure is not limited to such examples.

[0053]

(Example 1)

First, as raw materials for use, the following materials were prepared.

- Hydrogenated nitrile rubber ("Zetpol 158T" manufactured by ZEON Corporation, a combined acrylonitrile amount of 16.4% (by mass), a hydrogenation rate of 95.2%): 100 parts by mass

- Silica ("Nispil ER" manufactured by TOSOH Silica Corporation): 55 parts by mass
- Calcium carbonate ("Hakuenka CC" manufactured by Shiraishi Calcium Kaisha, Ltd.): 55 parts by mass
- Clay, kaolin clay ("KAOFINE" manufactured by Shiraishi Calcium Kaisha, Ltd.): 50 parts by mass
- Plasticizer, trioctyl trimellitate (2-ethylhexyl) (manufactured by Mitsubishi Chemical Corporation): 35 parts by mass
- Anti-aging agent, 4, 4'-bis (α, α-dimethylbenzyl) diphenylamine ("NOCRAC CD" manufactured by OUCHI Shinko Chemical Industrial Co., Ltd.): 1.5 parts by mass
- Vulcanizing agent, hexamethylenediamine carbamate ("Diak #1" manufactured by DuPont.): 2.1 parts by mass
- Vulcanization accelerator ("Rhenogran XLA-60" manufactured by LANXESS): 4.0 parts by mass

[0054]

Amounts of silica, calcium carbonate, clay and plasticizer to be blended were finely adjusted, without changing a total amount of an inorganic filler to be blended, so that rubber hardness was 70 degrees (according to JIS K6253-3), and blend components excluding the vulcanizing agent and vulcanization accelerator were thrown into a 1-liter kneader and kneaded, to prepare A-kneaded compound. Thereafter, the vulcanizing agent and vulcanization accelerator were blended, to perform B-kneading in a 6-inch roll, and a rubber compound was prepared.

[0055]

A mold having a cross sectional shape of the seal part 10 shown in FIG. 4 was filled with the obtained rubber compound (a filling ratio of 83% to a rectangular seal space of testing jigs 20 and 30 shown in FIG. 5, described later), and press vulcanization was performed at 170°C for 20 minutes. Furthermore, secondary vulcanization was performed at 170°C in an electric furnace for two hours, and a seal part of Example 1 was obtained.

[0056]

(Example 2)

Procedures similar to those of Example 1 were repeated, except that as hydrogenated nitrile rubber, "Zetpol 3610" manufactured by ZEON Corporation (a combined acrylonitrile amount of 20.5% (by mass), a hydrogenation rate of 95.2%) was used in place of "Zetpol 158T" manufactured by ZEON Corporation and amounts of silica, calcium carbonate, kaolin clay and plasticizer to be blended were appropriately adjusted, without changing a total amount of an inorganic filler to be blended, so that rubber hardness was 70 degrees (according to JIS K6253-3), to obtain a seal part of Example 2.

[0057]

(Example 3)

Procedures similar to those of Example 1 were repeated, except that an amount of silica ("Nispil ER" manufactured by TOSOH Silica Corporation) to be blended was 55 parts by mass, an amount of calcium carbonate ("Hakuenka CC" manufactured by Shiraishi Calcium Kaisha, Ltd.) to be blended was 35 parts by mass, an amount of clay, kaolin clay ("KAOFINE" manufactured by Shiraishi Calcium Kaisha, Ltd.) to be blended was 35 parts by mass, and a total amount of an inorganic filler to be blended was 125 mass%, to obtain a seal part of Example 3.

[0058]

(Example 4)

Procedures similar to those of Example 1 were repeated, except that as a polymer, 30 parts by mass of nitrile rubber ("Nipol DN2850" manufactured by ZEON Corporation, a combined acrylonitrile amount of 28% (by mass)) were additionally added and amounts of silica, calcium carbonate, kaolin clay and plasticizer to be blended were appropriately adjusted, without changing a total amount of an inorganic filler to be blended, so that rubber hardness was 70 degrees (according to JIS K6253-3), to obtain a seal part of Example 4.

[0059]

(Example 5)

Procedures similar to those of Example 1 were repeated, except that a spacer having a thickness of 0.1 mm and made of stainless steel was disposed in a bottom (in FIG. 5, apparently a top surface of a seal mounting groove 23, and this also applies to Example 7) of the seal mounting groove 23 of a jig 20 shown in FIG. 5, described later, to raise the bottom of the seal mounting groove 23 and compression seal was performed so that a filling ratio of the testing jigs 20 and 30 to a rectangular seal space was 90%, to obtain a seal part of Example 5.

[0060]

(Example 6)

Procedures similar to those of Example 1 were repeated, except that as a polymer, 50 parts by mass of nitrile rubber ("Zetpol DN2850" manufactured by ZEON Corporation, a combined acrylonitrile amount of 28% (by mass)) were additionally added and amounts of silica, calcium carbonate, kaolin clay and plasticizer to be blended were appropriately adjusted, without changing a total amount of an inorganic filler to be blended, so that rubber hardness was 70 degrees (according to JIS K6253-3), to obtain a seal part of Example 6.

[0061]

(Example 7)

Procedures similar to those of Example 1 were repeated, except that a spacer having a thickness of 0.5 mm and made of stainless steel was disposed in a bottom of a seal mounting groove 23 of the jig 20 shown in FIG. 5, described later, to further raise the bottom of the seal mounting groove 23 and compression seal was performed so that a filling ratio of the testing jigs 20 and 30 to a rectangular seal space was 93%, to obtain a seal part of Example 7.

[0062]

(Comparative Example 1)

Procedures similar to those of Example 1 were repeated, except that as hydrogenated nitrile rubber, "Zetpol 3710" manufactured by ZEON Corporation (a combined acrylonitrile amount of 23.4% (by mass), a hydrogenation rate of 95.2%) was used in place of "Zetpol 158T" manufactured by ZEON Corporation and amounts of silica, calcium carbonate, kaolin clay and plasticizer to be blended were appropriately adjusted, without changing a total amount of an inorganic filler to be blended, so that rubber hardness was 70 degrees (according to JIS K6253-3), to obtain a seal part of Comparative Example 1.

[0063]

(Comparative Example 2)

Procedures similar to those of Example 1 were repeated, except that an amount of silica ("Nispil ER" manufactured by TOSOH Silica Corporation) to be blended was 55 parts by mass, an amount of calcium carbonate ("Hakuenka CC" manufactured by Shiraishi Calcium Kaisha, Ltd.) to be blended was 20 parts by mass, an amount of kaolin clay ("KAOFINE" manufactured by Shiraishi Calcium Kaisha, Ltd.) to be blended was 20 parts by mass and a total amount of an inorganic filler to be blended was 95 mass%, to obtain a seal part of Comparative Example 2.

[0064]

Note that Table 1 below shows manufacturing conditions of the seal parts of Examples 1 to 7 and Comparative Examples 1 and 2 altogether.

[0065]

[Table 1]

	Combined acrylonitrile amount	Hydrogenation rate	Nitrile rubber blend ratio	Inorganic filler blend amount	Hardness	Filling ratio
Unit or the like	% (by mass)	%	Mass% (ratio to HNBR)	Mass%	Degree	y/x
Example1	16.4	95	0	160	70	0.83
Example2	20.5	95	0	160	70	0.83
Example3	16.4	95	0	125	70	0.83
Example4	16.4	95	30	160	70	0.83
Example5	16.4	95	0	160	70	0.90
Example6	16.4	95	50	160	70	0.83
Example7	16.4	95	0	160	70	0.93
Comparative Example1	23.4	95	0	160	70	0.83
Comparative Example2	16.4	95	0	95	60	0.83

[0066]

<Evaluation Test>

Respective evaluation tests were performed as follows, using the obtained seal parts of Examples 1 to 7 and Comparative Examples 1 and 2. Table 2 below shows results altogether.

[0067]

[Test of Resistance to Polycyclic Aromatic Component]

The jigs 20 and 30 shown in FIG. 5 and made of aluminum were prepared. The aluminum jig 30 imitates a cylinder head side of an engine, and the aluminum jig 20 imitates an intake manifold side. The aluminum jig 20 includes a liquid container having an elliptic shape with a long axis of 37 mm and a short axis of 25 mm and having a height of 15 mm, and a seal mounting groove 23 having a width of 3.5 mm and a depth of 5 mm is provided on an outer side at 5 mm from an opening edge.

[0068]

In the seal mounting groove 23 provided in the aluminum jig 20, the above described spacer made of stainless steel was disposed only in Examples 5 and 7, and each of the seal parts 10 of Examples 1 to 7 and Comparative Examples 1 to 2 was mounted. The aluminum jig 30 was pressed onto the seal part 10, and the seal part 10 was compressed with a compression allowance of

1.5 mm (a gap of 0.2 mm between the aluminum jig 30 and the aluminum jig 20).

[0069]

In a space formed between the aluminum jigs 20 and 30 and sealed with the seal part 10 (hereinafter referred to as "a containing space"), 8 ml of simulated polycyclic aromatic component-containing fuel oil (hereinafter referred to as "the simulated oil") was enclosed, held at 60°C in an explosion-proof constant temperature chamber of 60°C, and left to stand for 72 hours.

Note that in the simulated oil, 80 mass% of a mixed solvent (fuel oil C) of 50 vol% of isooctane + 50 vol% of toluene was mixed with 20 mass% of phenanthrene.

[0070]

Thereafter, the simulated oil was extracted from the containing space, and still in a state where the seal part 10 was set in the aluminum jig 20, a heat treatment was performed at 110°C for 24 hours.

After the heat treatment, the seal part set in the aluminum jig 20 was left to stand at -30°C in an environment for 4 hours, and an airtight test was performed.

In the airtight test, a pressure was raised every 10 kPa from -90 kPa up to 120 kPa, and the pressure at which air leakage occurred was recorded.

[0071]

Evaluation standards were as follows.

Double circle (excellent): 120 kPa or more

Circle (good): 50 kPa or more and less than 120 kPa

Cross (poor): less than 50 kPa

[0072]

[Resistance to Fuel Oil]

The aluminum jigs 20 and 30 shown in FIG. 5 and used in the test of the resistance to the polycyclic aromatic component were also used in a test of a resistance to fuel oil. In the containing space of the jig, 8 ml of a mixed solvent (the fuel oil C) of 50 vol% of isooctane + 50 vol% of toluene was enclosed, held at 60°C in the explosion-proof constant temperature chamber of 60°C, and left to stand for 72 hours.

[0073]

Thereafter, the fuel oil C was extracted from the containing space, the seal part 10 still set in the aluminum jig 20 was left to stand at -30°C in the environment for 4 hours, and then the airtight test was performed.

In the airtight test, the pressure was raised every 10 kPa from -90 kPa up to 120 kPa, and the pressure at which the air leakage occurred was recorded.

[0074]

Evaluation standards were as follows.

Double circle: 120 kPa or more

Circle: 50 kPa or more and less than 120 kPa

Triangle (fair): 30 kPa or more and less than 50 kPa

Cross: less than 30 kPa

[0075]

[Compression Set Property]

The aluminum jigs 20 and 30 shown in FIG. 5 and used in the test of the resistance to the polycyclic aromatic component were also used in a test of a compression set property. None was contained in the containing space of the jigs, and a heat aging test was performed at 150°C in the constant temperature chamber for 500 hours.

[0076]

Thereafter, the aluminum jigs 20 and 30 were removed from the constant temperature chamber, and left to stand at room temperature for 30 minutes. Thereafter, the seal part 10 was removed and opened from the aluminum jig 20, and a height (initially 6.7 mm) of the seal part 10 was measured, to obtain compression set from the following equation.

$$\text{Compression set (\%)} = (hi-ha)/1.5\times100,$$

in which hi indicates an initial seal height, and ha indicates a height of thermally aged seal.

[0077]

Evaluation standards were as follows.

Double circle: less than 50%

Circle: 50% or more and less than 70%

Triangle: 70% or more and less than 80%

Cross: The compression set is 80% or more.

[0078]

[Table 2]

	Resistance to polycyclic aromatic component (low temperature seal)	Resistance to fuel oil	Compression set property
Example1	◎	○	○
Example2	○	○	○
Example3	○	○	○
Example4	◎	○	○
Example5	◎	○	○
Example6	◎	○	△
Example7	◎	△	○
Comparative Example1	×	○	○
Comparative Example2	×	×	○

Reference Signs List

[0079]

1: seal part (seal part for engine intake system)

2: intake manifold

3: cylinder head

4: fuel injection device

5a: intake valve

5b: exhaust valve

6: cylinder

7: piston

10: seal part for test (seal part for engine intake system)

11: seal space

20: aluminum jig (intake manifold side)

21 and 23: seal mounting groove

22: opposite side surfaces

30: aluminum jig (cylinder head side)

What is claimed is:

1. A seal part for an engine intake system, comprising hydrogenated nitrile rubber in which a combined acrylonitrile amount is in a range of 15% to 20.5% by mass and a hydrogenation rate is 93% or more, and an inorganic filler having an amount of at least 125 parts by mass or more to be blended with 100 parts by mass of polymer content, wherein hardness is adjusted in a range of 63 to 77 degrees.

2. The seal part for the engine intake system according to claim 1, the seal part being subjected to peroxide vulcanization or amine vulcanization.

3. The seal part for the engine intake system according to claim 1, wherein the nitrile rubber in which the combined acrylonitrile amount is 20% or more by mass is blended with hydrogenated nitrile rubber within 30 mass%.

4. The seal part for the engine intake system according to any one of claims 1 to 3, the seal part being for use in a seal of a direct coupling portion between an engine cylinder head and an intake manifold.

5. A seal structure of an engine intake system which is a seal structure of a direct coupling portion between an engine cylinder head and an intake manifold, wherein:

the intake manifold includes a seal mounting groove,

the seal part for the engine intake system according to claim 4 is mounted in the seal mounting groove in a partially projected state, and an end in the projected state is pressed by a surface that forms the direct coupling portion of the cylinder head to the intake manifold,

in a cross section of the seal mounting groove, the seal part for the engine intake system is in contact with opposite side surfaces of the seal mounting groove, and a ratio (y/x) of a presence area (y) of a cross section of the seal part for the engine intake system to a cross sectional area (x) of a rectangular seal space surrounded with the cylinder head, the seal mounting groove and extensions of the opposite side surfaces of the groove is in a range of 0.75 to 0.90.

6. The seal structure of the engine intake system according to claim 5, wherein the intake manifold is made of a resin.

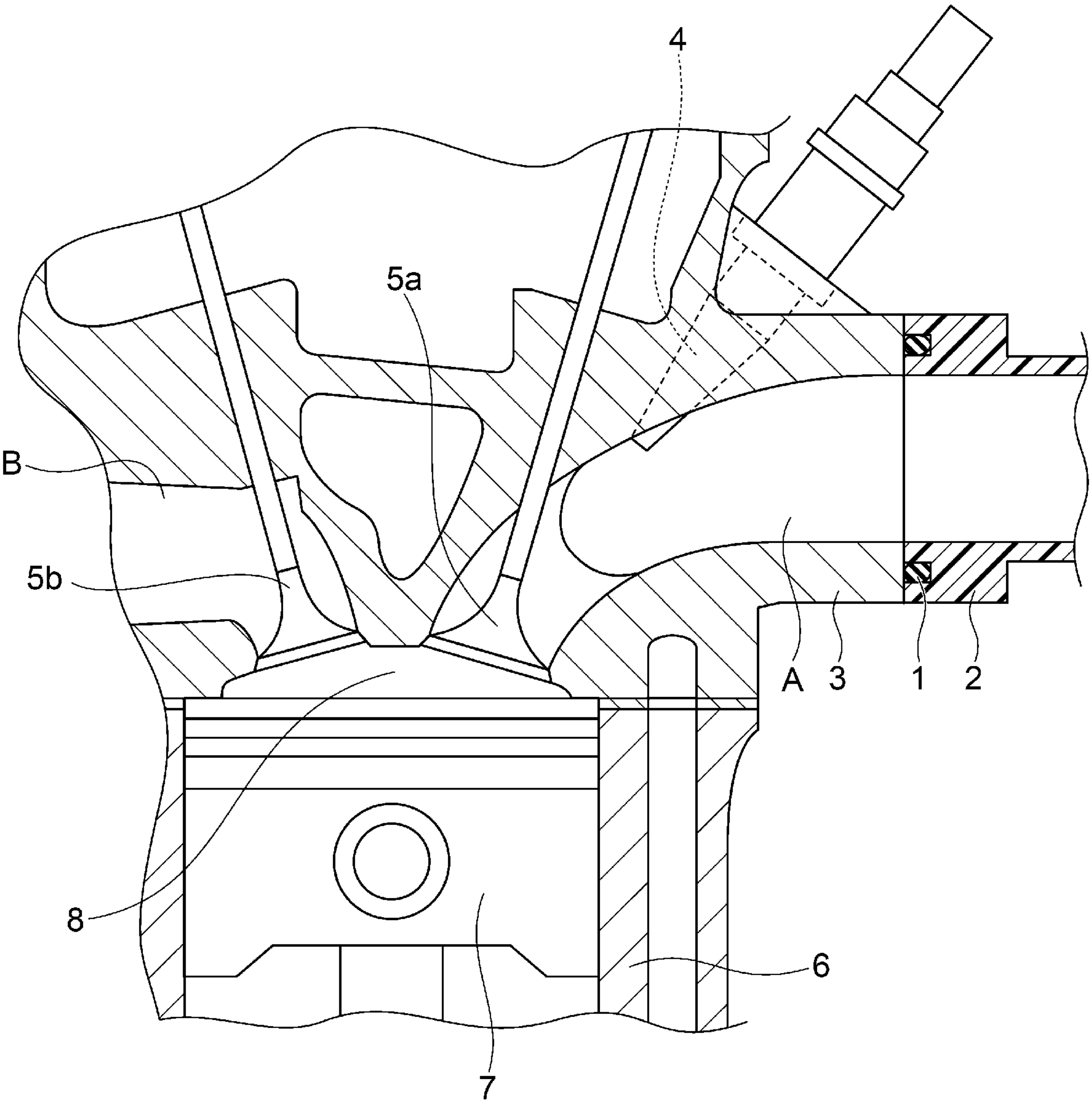

Fig. 1

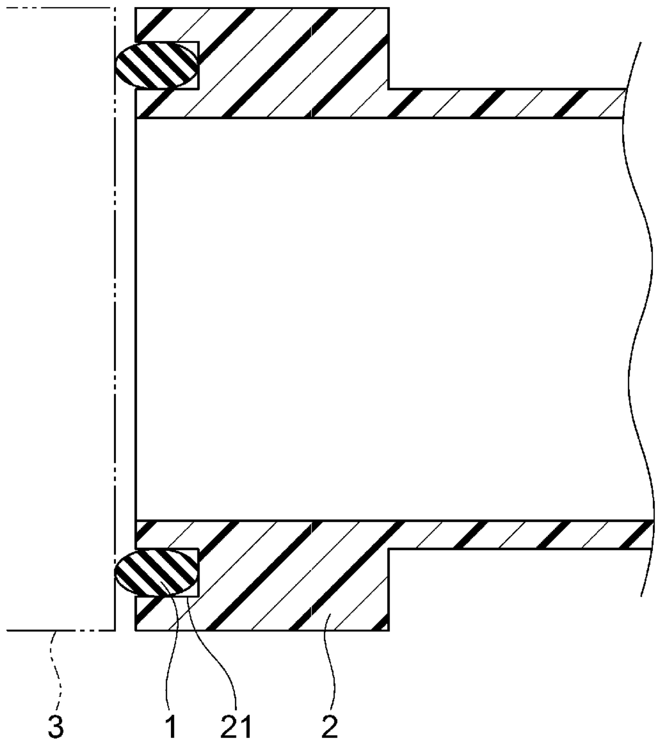

Fig. 2

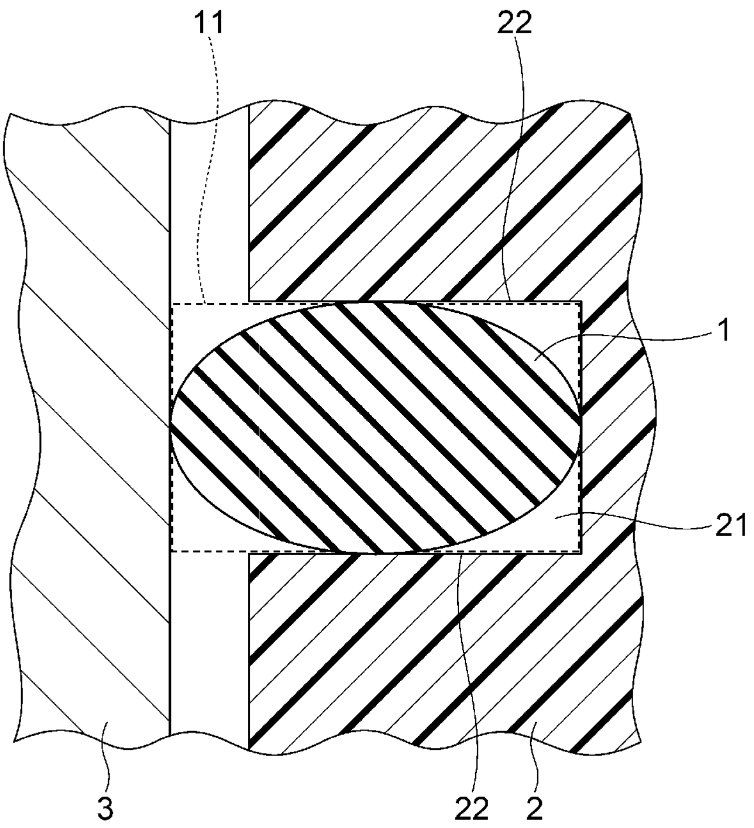

Fig. 3

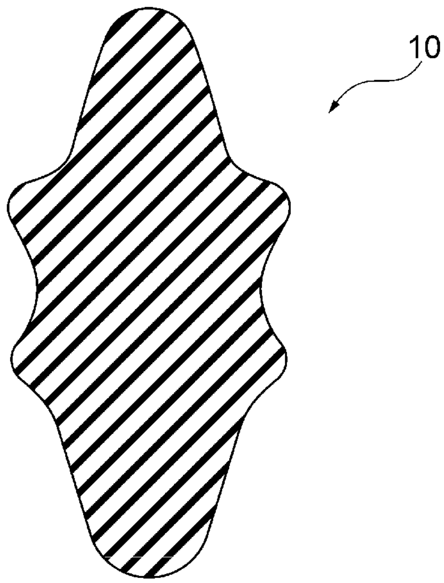

Fig. 4

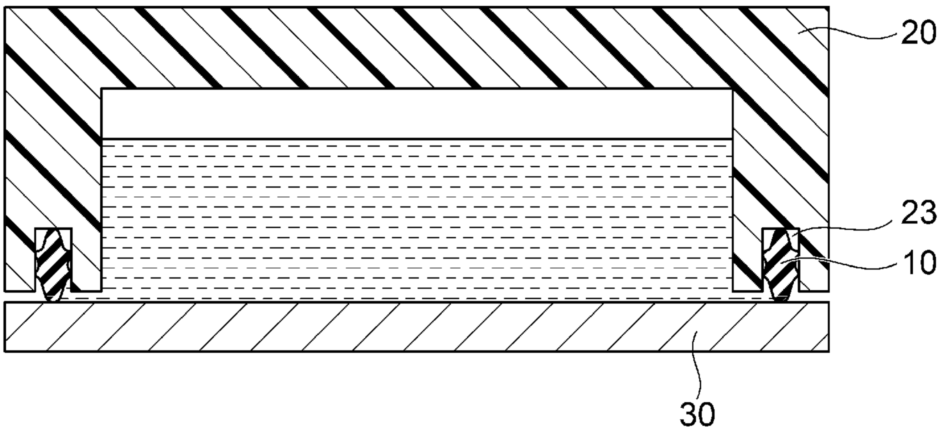

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/052841

A. CLASSIFICATION OF SUBJECT MATTER
INV. C08L15/00 C08L9/02
ADD.

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)
F02F C08L F16J

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	EP 2 857 447 A1 (NOK CORP [JP]) 8 April 2015 (2015-04-08) paragraphs [0013], [0035]; claims 1,6-8; example 1; table 1	1-4 5,6
X A	US 5 852 093 A (AIMURA YOSHIAKI [JP] ET AL) 22 December 1998 (1998-12-22) claims 1-6,10,11,12,15; table 1	1-4 5,6
A	EP 3 323 850 A1 (ZEON CORP [JP]) 23 May 2018 (2018-05-23) paragraphs [0059], [0093]; examples 11-13; table 1	1-6
A	US 2018/251628 A1 (SUGAWARA SHINSUKE [JP]) 6 September 2018 (2018-09-06) paragraphs [0006], [0116]; claims 1-10; tables 1,2	1-6

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

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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
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Date of the actual completion of the international search	Date of mailing of the international search report
8 May 2020	18/05/2020

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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