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(54) SLIDING MATERIAL COMPOSITION AND SLIDING MEMBER

(57) It is an object of the invention to provide a sliding material composition and a sliding member capable of achieving low friction property at starting time and during sliding and also being excellent in abrasion resistance, especially when a counterpart sliding member is a rubber-based material. The invention relates to a sliding material composition for use in a sliding member whose counterpart sliding member is configured of rubber, the sliding material composition comprising a binder resin, 5 to 25 vol% of an Nω-monoacyl basic amino acid, 5 to 25 vol% of molybdenum disulfide, and 5 to 20 vol% of polytetrafluoroethylene.

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Description

Technical Field

[0001] The present invention relates to a sliding material composition and a sliding member and, in particular, relates to a sliding material composition suitable for a sliding member whose counterpart sliding material is configured of rubber.

Background Art

[0002] Conventionally, for the purpose of realizing lubrication of sliding parts of machinery, coating a sliding material composition on a surface of each sliding part to make the sliding material composition function as a lubricating film at the sliding part have been carried out. Accordingly, such a kind of sliding material composition is required to be a lubricating film low in friction, excellent in abrasion resistance so as not to abrade even when being used for a long period of time, and having high fitness with a counterpart sliding material.

[0003] As a conventional sliding material composition, there is known, for example, a sliding material composition containing a binder resin, a solid lubricant, and an Nω-monoacyl basic amino acid (refer to patent document 1), a sliding material composition containing a heat resisting resin, a fluorine resin, a solid lubricant, organopolysiloxane, and an organic solvent (refer to patent document 2).

Prior Art Document

Patent Document

[0004]

[Patent Document 1] JP-A-2004-10707
[Patent Document 2] JP-A-H08-109352

Summary of the Invention

Problem that the Invention is to solve

[0005] The sliding material composition described in patent document 1 is low in friction and excellent in abrasion resistance in the case of sliding under no lubrication condition, i.e., in a dry state where there is no fluid lubrication such as oil and grease. However, there is a problem such that a coefficient of friction is large in the case of sliding under mixed lubrication, i.e., under a condition where each of fluid lubrication (lubrication in an atmosphere where there is oil or grease) and boundary lubrication (lubrication in an atmosphere where there is no oil or grease) may occur, particularly when the counterpart sliding member is a rubber-based material.

[0006] Further, although the sliding material composition described in patent document 2 does not reduce adhering property, coefficient of friction and baking resistance of the coating, a decreasing effect of the coefficient of friction at starting time cannot be obtained, and further, abrasion resistance is not sufficient.

[0007] It is an object of the invention to provide a sliding material composition and a sliding member capable of achieving low friction property at starting time and during sliding and also being excellent in abrasion resistance, especially when a counterpart sliding member is a rubber-based material.

Means for Solving the Problems

[0008] In consideration of the above-described problems, the present inventors have completed the invention by founding that a low friction effect can be obtained by lowering coefficient of static friction, since the rubber, which is an elastic body, is high in hysteresis in sliding against a rubber-based material and a coefficient of static friction at starting of sliding is high, and by obtaining knowledge on abrasion resistance. That is, the invention relates to a sliding material composition and a sliding member described hereinafter.

[1] A sliding material composition for use in a sliding member whose counterpart sliding member is configured of rubber, the sliding material composition comprising: a binder resin; 5 to 25 vol% of an Nω-monoacyl basic amino acid; 5 to 25 vol% of molybdenum disulfide; and 5 to 20 vol% of polytetrafluoroethylene (PTFE).
[2] The sliding material composition according to the above [1], wherein a ratio of a content of the polytetrafluoroethylene to a content of the molybdenum disulfide on a volume basis is 0.5 to 2.0.

[3] The sliding material composition according to the above [1] or [2], wherein, taking a total content of the molybdenum disulfide and polytetrafluoroethylene as X and a content of the Nω-monoacyl basic amino acid as Y, a ratio of X to Y satisfies a relationship of $2 \leq X/Y \leq 3$ on a volume basis.
[4] The sliding material composition according to any of the above [1] to [3], further comprising: 10 vol% or less of at least one kind of solid lubricant selected from a group consisting of graphite, tungsten disulfide, mica, a fluorine resin other than polytetrafluoroethylene, boron nitride, graphite fluoride, and fullerene.
[5] The sliding material composition according to any of the above [1] to [4], further comprising: at least one kind of inorganic additive selected from a group consisting of SiC, alumina, Si_3N_4, TiO_2, SiO_2, calcium carbonate, barium sulfate, and calcium phosphate.
[6] The sliding material composition according to any of above [1] to [5], wherein the binder resin is at least one kind of resin selected from a group consisting of a polyamideimide resin, a polyimide resin, a phenol resin, a polyacetal resin, a polyether ether ketone resin, and a polyphenylene sulfide resin.
[7] A sliding member whose counterpart sliding member is configured of rubber, the sliding member comprising: a base material formed of a material selected from the group consisting of iron and steel, stainless steel, cast iron, copper, copper alloy, aluminum, aluminum alloy, rubber, plastics and ceramics; and a coating layer provided on the surface of the base material and including: a binder resin, 5 to 25 vol% of an Nω-monoacyl basic amino acid, 5 to 25 vol% of molybdenum disulfide, and 5 to 20 vol% of polytetrafluoroethylene.
[8] The sliding member according to the above [7], wherein a ratio of a content of the polytetratluoroethylene to a content of the molybdenum disulfide in the coating layer on a volume basis is 0.5 to 2.0.
[9] The sliding member according to the above [7] or [8], wherein, taking a total content of the molybdenum disulfide and polytetrafluoroethylene as X and a content of the Nω-monoacyl basic amino acid as Y in the coating layer, a ratio of X to Y satisfies a relationship of $2 \leq X/Y \leq 3$ on a volume basis.
[10] The sliding member according to any of the above [7] to [9], wherein the coating layer contains 10 vol% or less of at least one kind of solid lubricant selected from a group consisting of graphite, tungsten disulfide, mica, a fluorine resin other than polytetrafluoroethylene, boron nitride, graphite fluoride, and fullerene.
[11] The sliding member according to any of the above [7] to [10], wherein the coating layer contains at least one kind of inorganic additive selected from a group consisting of SiC, alumina, Si_3N_4, TiO_2, SiO_2 calcium carbonate, barium sulfate, and calcium phosphate.
[12] The sliding member according to any of the above [7] to [11], wherein the binder resin is at least one kind of resin selected from a group consisting of a polyamideimide resin, a polyimide resin, a phenol resin, a polyacetal resin, a polyether ether ketone resin, and a polyphenylene sulfide resin.
[13] The sliding member according to any of the above [7] to [12], wherein the counterpart sliding member is a sealing component of a hub bearing part for a vehicle.

Advantage of the Invention

[0009] According to the invention, a sliding material composition and a sliding member capable of achieving a low abrasion property at starting time and during sliding and being excellent in abrasion resistance, especially when the counterpart sliding member is a rubber-based material, can be provided.

Brief Description of the Drawings

[0010]

Fig. 1 is a schematic drawing of a reciprocating sliding testing machine used in the Examples.
Fig. 2 (a) and 2 (b) are schematic drawings of friction torque testing machines used in the Examples; Fig 2 (a) is a schematic drawing of a top face of the testing machine, and Fig. 2 (b) is a schematic sectional view of a bearing used in a test.
Fig. 3 is a graph showing results of friction torque tests.

Mode for Carrying Out the Invention

[0011] A sliding material composition according to the invention (hereinafter also referred to as "the composition of the invention") comprises a binder resin, 5 to 25 vol% of an Nω-monoacyl basic amino acid, 5 to 25 vol% of molybdenum disulfide, and 5 to 20 vol% of polytetrafluoroethylene (PTF).
[0012] The binder resin is a material having a function of binding the composition of the invention, and the binder resin is preferably at least one kind of resin selected from the group consisting of a polyamideimide (PAI) resin, a polyimide resin, a phenol resin, a polyacetal resin, a polyether ether ketone resin, and a polyphenylene sulfide resin. Among these

resins, the polyamideimide (PAI) resin is preferably used from the point of abrasion resistance.

[0013] The composition of the invention contains three kinds of solid lubricants of the Nω-monoacyl basic amino acid, molybdenum disulfide, and PTF, each in a prescribed amount.

In sliding against rubber of a counterpart material which is an elastic body, a coefficient of friction shifts from a coefficient of static friction to a coefficient of dynamic friction when one portion starts to move, and so the sliding is liable to be influenced by a lubricant having a lower coefficient of friction among the lubricants blended. Contrary to this, in the case of sliding in which the counterpart material is a rigid material, the coefficient of friction does not shift to the coefficient of dynamic friction until the entire starts to move, and so the sliding is liable to be influenced by the lubricant having a higher coefficient of friction among the lubricants blended. In view of the above fact, the composition of the invention contains three kinds of solid lubricants. The first solid lubricant lowers the coefficient of static friction at starting time. The second solid lubricant lowers the coefficient of dynamic friction and is capable of obtaining abrasion resistance. The third solid lubricant lowers the coefficient of dynamic friction in the case of being out of a grease, i.e., in the case of no lubrication. The invention adopted the Nω-monoacyl basic amino acid, which is an amino acid-based solid lubricant, as the first solid lubricant, molybdenum disulfide (MoS_2) as the second solid lubricant, and PTFE as the third solid lubricant.

[0014] As a specific example of the Nω-monoacyl basic amino acid, Nε-lauroyl-L-lysine is exemplified. Nε-Lauroyl-L-lysine is characterized in that it is low in friction property. Accordingly, a low frictional coating composition can be obtained by binding Nε-lauroyl-L-lysine with a binder resin. Since Nε-lauroyl-L-lysine is lower than PTFE and the like in intensity, reduction of abrasion resistance can be suppressed when a solid lubricant such as PTFE coexists. Further, a composite layer of Nε-Lauroyl-L-lysine and the solid lubricant is formed between a counterpart axis and the sliding face during sliding, and therefore, friction is reduced. With the reduction of friction, exothermic temperature of the sliding surface is suppressed, which leads to restraint of damages of the resin composition and composition transferred layer. As a result, excellent abrasion resistance can be obtained.

[0015] However, since retention of oil in grease is not sufficient with Nω-monoacyl basic amino acid alone, a low friction effect can be exhibited by the use of molybdenum disulfide having good oil retention in combination, and abrasion resistance is also improved. Further, by blending PTFE, since the lubricating component is compensated when the composition is out of oil, a low friction effect can be expected. Under grease lubrication, since oil is compensated or runs out by sliding or the like, low friction and the effect of excellent abrasion resistance can be exhibited by the addition of both molybdenum disulfide and PTFE, with or without oil.

[0016] In the invention, Nω-monoacyl basic amino acid can be easily obtained by introduction of a hydrophobic acyl group into an ω basic amino acid. The examples of the basic amino acids for constituting the Nω-monoacyl basic amino acid for use in the invention include lysine, ornithine and the like, and they may be an optically active substance or a racemic body. The acyl group is preferably a saturated or unsaturated aliphatic acyl group having 8 to 22 carbon atoms. As the preferred specific example of the Nω-monoacyl basic amino acid, Nε-lauroyl-L-lysine is exemplified.

[0017] The content of the Nω-monoacyl basic amino acid in the composition is 5 to 25 vol% and preferably 5 to 15 vol%. When the content of Nω-monoacyl basic amino acid is in the above range, a good initial low friction effect can be obtained.

[0018] The content of molybdenum disulfide in the composition of the invention is 5 to 25 vol% and preferably 5 to 15 vol%. When the content of molybdenum disulfide is in the above range, a good abrasion resistance can be obtained. The average particle size of molybdenum disulfide is preferably 0.5 μm to 20 μm, and more preferably 1 μm to 10 μm.

[0019] The content of polytetratluoroethylene (PTFE) in the composition of the invention is 5 to 20 vol% and preferably 5%to 15 vol%. When the content of PTFE is in the above range, a good low friction effect can be obtained.

Incidentally, the average particle size of PTFE is preferably 0.5 μm to 20 μm, and more preferably I μm to 10 μm.

[0020] Further, a ratio of a content of PTFE to a content of molybdenum disulfide is preferably 0.5 to 2.0 on a volume basis. When the above ratio is 0.5 or more, the oil in the grease is sufficiently retained, and friction can be lowered and excellent abrasion resistance can be secured, and is therefore preferable. Further, when the ratio is 2.0 or less, the coefficient of friction is difficult to increase even when the oil in the grease runs out, and is therefore preferable.

[0021] Further, in the case where a total content of the molybdenum disulfide and PTFE is taken as X and a content of the Nω-monoacyl basic amino acid is taken as Y, it is preferred that a ratio of X to Y satisfies a relationship of $2 \leq X/Y \leq 3$ on a volume basis. When X/Y is 2 or more, the oil in the grease is sufficiently retained and the coefficient of friction can be lessened, and is therefore preferable. Further, when X/Y is 3 or less, the low friction effect of the Nω-monoacyl basic amino acid becomes sufficient and the coefficient of friction can be lessened, and is therefore preferable.

[0022] The composition of the invention may contain solid lubricants other than the above solid lubricants from the point of imparting a low friction property, and inorganic additives in view of providing abrasion resistance.

As the solid lubricants other than the above solid lubricants, at least one kind of solid lubricant selected from a group consisting of graphite, tungsten disulfide, mica, a fluorine resin other than PTFE, boron nitride, graphite fluoride, and fullerene is preferable. Also, from the point of low friction, the content of the solid lubricant in the composition is preferably 10 vol% or less.

[0023] As the inorganic additive, at least one kind of inorganic additive selected from a group consisting of SiC, alumina,

Si_3N_4, TiO_2, SiO_2, calcium carbonate, barium sulfate, and calcium phosphate is preferable. Also, from the viewpoint of abrasion resistance, the content of the inorganic additive in the composition is preferably 1 to 5 vol%.

[0024] The sliding material composition according to the invention can be used as a coating layer of a base material surface of the sliding member. In particular, the sliding material composition of the invention is suitable for coating on the sliding surface in the case where the counterpart sliding member is rubber. As the counterpart sliding member, a sealing component for a hub bearing part for a vehicle may be specifically exemplified.

[0025] The material of the base material of the sliding member according to the invention is not especially restricted, but a material selected from a group consisting of iron and steel, stainless steel, cast iron, copper, copper alloy, aluminum, aluminum alloy, rubber, plastics and ceramics is preferable. A shape of the base material is not especially restricted, and may be plate-like or tube-like.

[0026] As the forming method of the coating layer, for example, a method of mixing the composition of the invention with a solvent of a resin, forming a film with a known method such as air spray coating or the like, and baking the film at a baking temperature of the resin can be applied. Further, in order to strengthen the coating, surface roughening treatment may be carried out prior to coating of the base material surface, or an adhesive layer may be provided between the base material and the coating layer. A thickness of the coating layer is preferably 5 μm to 30 μm. The surface roughness of the coating layer is not especially restricted, but is preferably 0.3 μm Ra to 3 μm Ra.

[0027] The lubrication condition of the sliding member according to the invention is not especially restricted, and can be used in any of oil lubrication, grease lubrication and no lubrication.

Examples

<Examples 1 to 9 and Comparative Examples 1 to 7>

[0028] After performing shot blasting treatment to a SUS base material (about 0.8 mm in thickness), the SUS base material was spray coated with a composition shown in the following Table I in a thickness of about 15 μm. Incidentally, Amihope LL (registered trademark) of Ajinomoto Co., Inc. was used as the Nε-lauroyl-L-lysine, and HPC-5300 of Hitachi Chemical Co., Ltd. was used as the polyamideimide (PAI) resin. An average particle size of graphite was 1 μm, and an average particle size of molybdenum disulfide was 1.0 μm. After forming a film by spray coating, the obtained film was baked at 200°C to prepare a test specimen.

Each of the test specimens in the Examples and the Comparative Examples was subjected to a reciprocating sliding test, and the coefficient of friction and abrasion loss of each test specimen were measured. The test specimen in Example 5 was subjected to a friction torque test. The results of the reciprocating sliding test are shown in Table 1 and the results of the friction torque test are shown in Fig. 3.

<Reciprocating Sliding Test>

[0029]

Testing machine: Reciprocating sliding testing machine (Fig. 1)
Load: 9.8N
Stroke: 5 mm
Frequency: 5 Hz
Reciprocating times: 200 times
Temperature: Room temperature
Lubrication: Grease coating
Velocity: 50 m/s
Material of counterpart sliding member: Rubber (NBR)
The results of the tests are shown in Table 1 below.

[0030]

[Table 1]

		Compositional Ratio (vol%)							Coefficient of Friction		
		PAI	Epoxy Resin	Nω-Lauroryl-L-lysine	MoS_2	PTFE	Graphite	SiC	Maximum Coefficient of Friction at Starting Time	Coefficient ot Dynamic Friction	Abrasion Loss (μm)
Example	1	64	-	25	5	5	-	1	0.15	0.08	2.1
	2	60	-	20	10	10	-	-	0.13	0.06	1.5
	3	62	-	15	8	10	5	-	0.14	0.07	1.8
	4	60	-	10	10	20	-	-	0.12	0.05	1.3
	5	70	-	10	10	10	-	-	0.10	0.04	1.0
	6	60	-	10	20	10	-	-	0.13	0.05	1.2
	7	75	-	5	10	10	-	-	0.15	0.09	1.5
	8	70	-	10	15	5	-	-	0.30	0.13	3.2
	9	60	-	20	5	15	-	-	0.31	0.12	3.5
Comparative Eaxmple	1	60	-	-	20	20	-	-	0.38	0.15	4.7
	2	80	-	-	-	10	10	-	0.44	0.15	5.6
	3	57	-	3	20	20	-	-	0.25	0.11	4.5
	4	60	-	40	-	-	-	-	0.52	020	15.0
	5	-	60	-	20	10	10	-	0.49	0.23	8.3
	6	80	-	-	10	5	5	-	0.27	0.15	8.3
	7	70	-	10	20	-	-	-	0.20	0.12	4.0

[0031] It can be seen that the coefficient of friction is low at the starting time and during sliding and also excellent in abrasion resistance in every case of using the composition of the Example.

<Friction Torque Test>

[0032] By using the testing machines shown in Fig. 2 (a) and Fig. 2 (b) and changing the bearing rotation number in the range of 100 rpm to 800 rpm, a reduction effect of torque under grease lubrication was compared in the case of using the sliding material composition in Example 5 and in the case of not using a sliding material composition (i.e., only SUS).
The result of the test is shown in Fig. 3.
[0033] In the case of using the sliding material composition in Example 5, a maximum reduction effect of friction torque of 4.5% was obtained at 400 rpm.
[0034] While the invention has been described in detail with reference to specific embodiments thereof, it will be apparent to one skilled in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof. The present application is related to Japanese patent application filed on February 18, 2011 (Japanese Patent Application No. 2011-032811), and the disclosure of which is incorporated herein by reference.

Claims

1. A sliding material composition for use in a sliding member whose counterpart sliding member is configured of rubber, the sliding material composition comprising:

    a binder resin;

        5 to 25 vol% of an Nω-monoacyl basic amino acid;
        5 to 25 vol% of molybdenum disulfide; and
        5 to 20 vol% of polytetrafluoroethylene.

2. The sliding material composition according to claim 1,
wherein a ratio of a content of the polytetrafluoroethylene to a content of the molybdenum disulfide on a volume basis is 0.5 to 2.0.

3. The sliding material composition according to claim 1 or 2,
wherein, taking a total content of the molybdenum disulfide and polytetratluoroethylene as X and a content of the Nω-monoacyl basic amino acid as Y, a ratio of X to Y satisfies a relationship of $2 \leq X/Y \leq$ on a volume basis.

4. The sliding material composition according to any of claims 1 to 3, further comprising: 10 vol% or less of at least one kind of solid lubricant selected from a group consisting of graphite, tungsten disulfide, mica, a fluorine resin other than polytetrafluoroethylene, boron nitride, graphite fluoride, and fullerene.

5. The sliding material composition according to any of claims 1 to 4, further comprising: at least one kind of inorganic additive selected from a group consisting of SiC, alumina, Si_3N_4, TiO_2, SiO_2, calcium carbonate, barium sulfate, and calcium phosphate.

6. The sliding material composition according to any of claims 1 to 5,
wherein the binder resin is at least one kind of resin selected from a group consisting of a polyamideimide resin, a polyimide resin, a phenol resin, a polyacetal resin, a polyether ether ketone resin, and a polyphenylene sulfide resin.

7. A sliding member whose counterpart sliding member is configured of rubber, the sliding member comprising:

    a base material formed of a material selected from the group consisting of iron and steel, stainless steel, cast iron, copper, copper alloy, aluminum, aluminum alloy, rubber, plastics and ceramics; and
    a coating layer provided on the surface of the base material and including:

        a binder resin,

            5 to 25 vol% of an Nω-monoacyl basic amino acid,

5 to 25 vol% of molybdenum disulfide, and
5 to 20 vol% of polytetrafluoroethylene.

8. The sliding member according to claim 7,
wherein a ratio of a content of the polytetrafluoroethylene to a content of the molybdenum disulfide in the coating layer on a volume basis is 0.5 to 2.0.

9. The sliding member according to claim 7 or 8,
wherein, taking a total content of the molybdenum disulfide and polytetrafluoroethylene as X and a content of the Nω-monoacyl basic amino acid as Y in the coating layer, a ratio of X to Y satisfies a relationship of $2 \leq X/Y \leq 3$ on a volume basis.

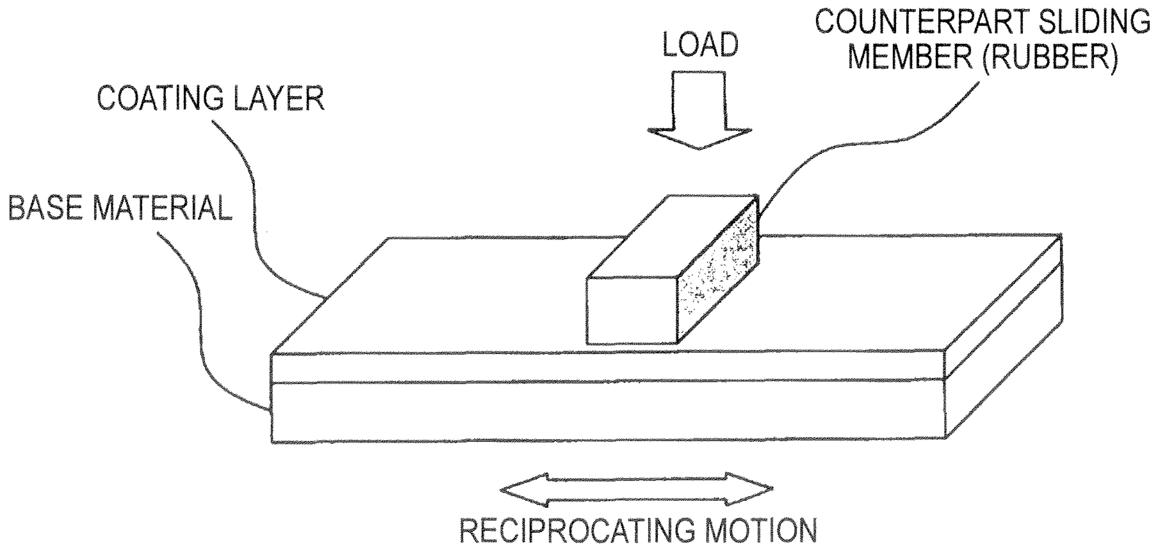
10. The sliding member according to any of claims 7 to 9,
wherein the coating layer contains 10 vol% or less of at least one kind of solid lubricant selected from a group consisting of graphite, tungsten disulfide, mica, a fluorine resin other than polytetrafluoroethylene, boron nitride, graphite fluoride, and fullerene.

11. The sliding member according to any of claims 7 to 10,
wherein the coating layer contains at least one kind of inorganic additive selected from a group consisting of SiC, alumina, Si_3N_4, TiO_2, SiO_2, calcium carbonate, barium sulfate, and calcium phosphate.

12. The sliding member according to any of claims 7 to 11,
wherein the binder resin is at least one kind of resin selected from a group consisting of a polyamideimide resin, a polyimide resin, a phenol resin, a polyacetal resin, a polyether ether ketone resin, and a polyphenylene sulfide resin.

13. The sliding member according to any of claims 7 to 12,
wherein the counterpart sliding member is a sealing component of a hub bearing part for a vehicle.

FIG. 1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COATING LAYER
BASE MATERIAL
RECIPROCATING MOTION

FIG. 2

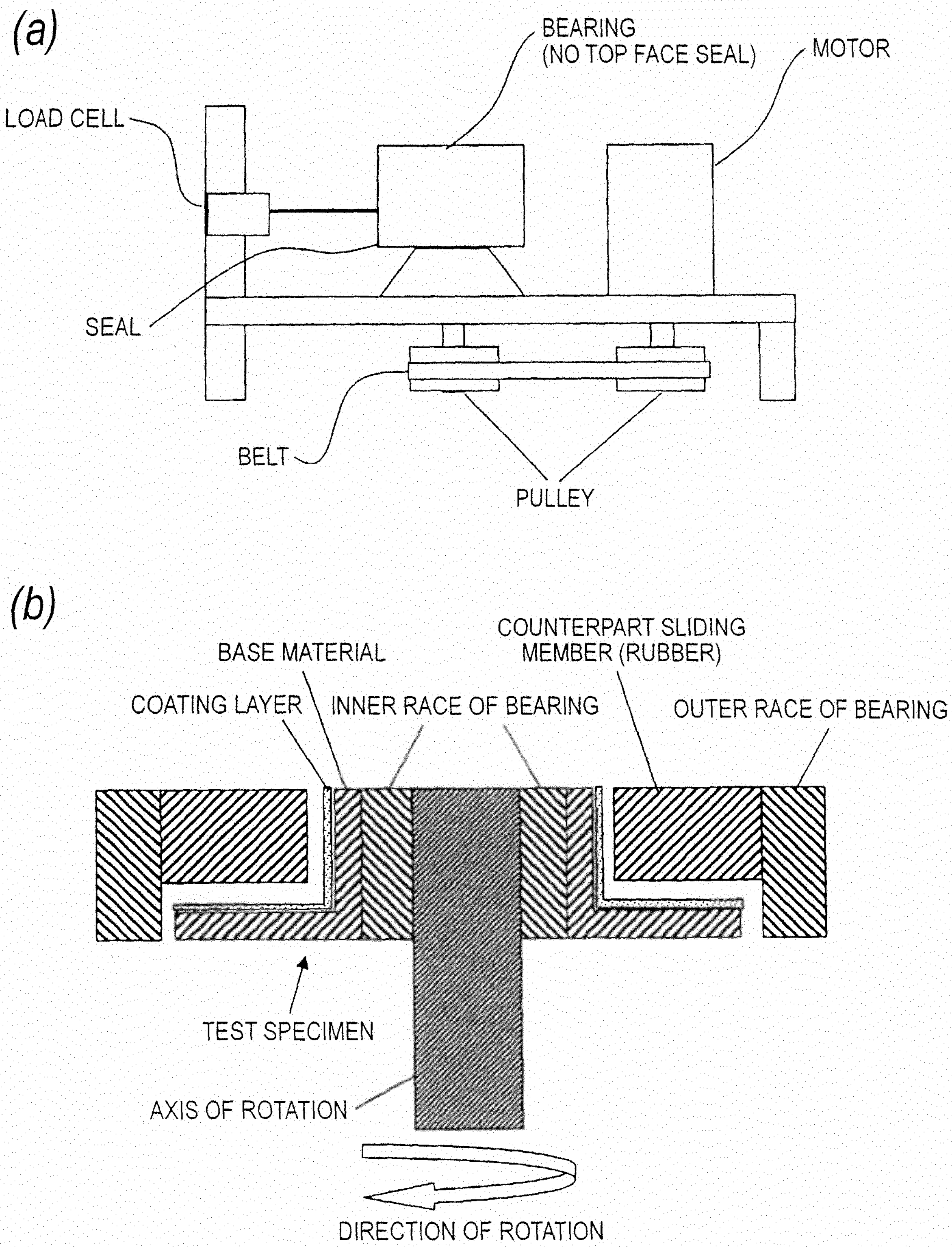
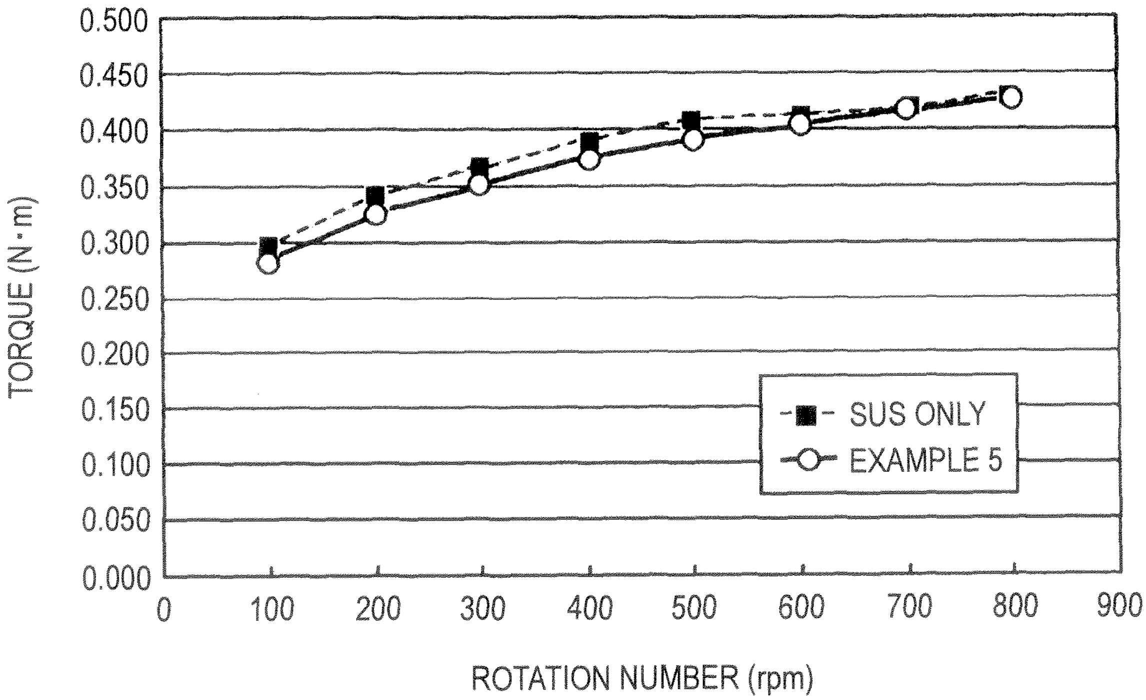

(a)
BEARING
(NO TOP FACE SEAL)
MOTOR
LOAD CELL
SEAL
BELT
PULLEY
(b)
BASE MATERIAL
COUNTERPART SLIDING
MEMBER (RUBBER)
COATING LAYER
INNER RACE OF BEARING
OUTER RACE OF BEARING
TEST SPECIMEN
AXIS OF ROTATION
DIRECTION OF ROTATION

FIG. 3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0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
TORQUE (N·m)
0
100
200
300
400
500
600
700
800
900
ROTATION NUMBER (rpm)
SUS ONLY
EXAMPLE 5

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2012/053711

A. CLASSIFICATION OF SUBJECT MATTER

See extra sheet.

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)
C10M169/04, C10M103/06, C10M105/60, C10M107/38, C10M125/02, C10M125/10, C10M125/18, C10M125/22, C10M125/24, C10M125/26, C10M133/06, C10M145/04, C10M145/20, C10M145/22, C10M147/02, C10M149/18, C10M151/04, C10N30/06,

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
CA/REGISTRY(STN), JSTPlus/JMEDPlus/JST7580(JDreamII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2004-10707 A (Taiho Kogyo Co., Ltd.), 15 January 2004 (15.01.2004), claims; examples (Family: none)	1-13 1-13
Y	JP 2008-56750 A (Sumico Lubricant Co., Ltd.), 13 March 2008 (13.03.2008), claims; examples & US 2008/0060603 A1 & EP 1894987 A1	1-13
Y	JP 2009-68390 A (Toyota Motor Corp., Dow Corning Toray Co., Ltd., Art Metal Mfg. Co., Ltd.), 02 April 2009 (02.04.2009), claims; examples (Family: none)	1-13

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

* Special categories of cited documents:
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Date of the actual completion of the international search 08 May, 2012 (08.05.12)	Date of mailing of the international search report 22 May, 2012 (22.05.12)
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INTERNATIONAL SEARCH REPORT

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 7-97517 A (Toyota Motor Corp., Dow Corning Asia, Ltd.), 11 April 1995 (11.04.1995), claims; examples & US 5486299 A	1-13
Y	JP 2007-9039 A (Sumico Lubricant Co., Ltd.), 18 January 2007 (18.01.2007), claims; examples (Family: none)	1-13

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/053711

Continuation of A. CLASSIFICATION OF SUBJECT MATTER
(International Patent Classification (IPC))

C10M169/04(2006.01)i, *C10M103/06*(2006.01)i, *C10M105/60*(2006.01)i, *C10M107/38*(2006.01)i, *C10M125/02*(2006.01)i, *C10M125/10*(2006.01)i, *C10M125/18*(2006.01)i, *C10M125/22*(2006.01)i, *C10M125/24*(2006.01)i, *C10M125/26*(2006.01)i, *C10M133/06*(2006.01)i, *C10M145/04*(2006.01)i, *C10M145/20*(2006.01)i, *C10M145/22*(2006.01)i, *C10M147/02*(2006.01)i, *C10M149/18*(2006.01)i, *C10M151/04*(2006.01)i, *C10N30/06*(2006.01)n, *C10N40/02*(2006.01)n

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Continuation of B. FIELDS SEARCHED
Minimum documentation searched (International Patent Classification (IPC))

C10N40/02

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REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2004010707 A **[0004]**
- JP H08109352 A **[0004]**
- JP 2011032811 A **[0034]**