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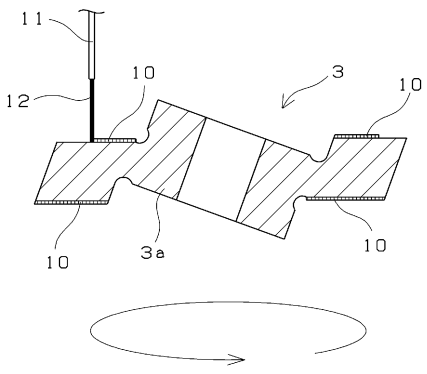
(54) SWASH PLATE FOR SWASH PLATE COMPRESSOR, METHOD FOR MANUFACTURING SAME, AND SWASH PLATE COMPRESSOR

(57) The present invention provides a resin coating-provided swash plate, for a swash plate compressor, manufactured in a manufacturing method which includes a process shorter than a process of a conventional coating method and which allows the resin coating to be subjected to grinding processing with high accuracy and to have a high strength of adhesion to a base material of the swash plate, a method for manufacturing the swash plate, and the swash plate compressor having the swash plate. A swash plate (3) for a swash plate compressor is so constructed that inside a housing where a refrigerant is present, a rotational motion of the swash plate (3) mounted perpendicularly and obliquely on a rotational shaft by directly fixing the swash plate (3) thereto or indirectly fixing the swash plate thereto through a coupling member to the rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on the swash plate (3) to compress and expand the refrigerant. A resin coating (10) is formed on a sliding contact surface of the swash plate (3) on which the shoe slides and has a layered structure in which a plurality of layers lie one upon another in a direction parallel with the sliding contact surface in an axial cross section thereof. The resin coating (10) is formed by linearly applying resin paint (12) discharged from a discharge port (11) to a base material (3a) of the swash plate (3).

Fig.4



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Description

TECHNICAL FIELD

[0001] The present invention relates to a swash plate for a swash plate compressor for use in an air conditioner and the like, a method for manufacturing the swash plate, and the swash plate compressor having the swash plate.

BACKGROUND ART

[0002] The swash plate compressor is so constructed that inside a housing where a refrigerant is present, a rotational motion of a swash plate mounted perpendicularly or obliquely on a rotational shaft by directly fixing the swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to the rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on the swash plate to compress and expand the refrigerant. The swash plate compressor is classified into a double swash plate type of compressing and expanding the refrigerant at both sides of the swash plate by using a double head type piston and a single swash plate type of compressing and expanding the refrigerant at one side thereof by using a single head type piston. The shoe includes a type which slides on only one side surface of the swash plate and a type which slides on both side surfaces thereof.

[0003] In an early stage of an operation of the swash plate compressor, there is a case in which the metallic shoe slides on the metallic swash plate before lubricating oil reaches the inside of the housing in which the refrigerant is present. Thus the sliding-contact portion of the shoe and that of the swash plate have a dry lubricated state in which the lubricating oil is not supplied to the sliding-contact portion of the swash plate and that of the shoe. As a result, the sliding-contact portions are liable to have seizing.

[0004] As means for preventing the occurrence of seizing, there is proposed the metallic swash plate in which through the intermediate layer, the sliding contact layer containing thermosetting resin and the solid lubricant selected from among molybdenum disulfide and graphite is formed on the sliding contact surface of the metallic swash plate on which the shoe slides (see patent document 1). Another swash plate for a swash plate compressor is proposed. The base material of the swash plate is disk-shaped by subjecting a rolled steel plate to pressing processing. Both surfaces of the base material of the swash plate are subjected to grinding processing to form the sliding contact surface on which a shoe slides. The low-friction resin coating layer containing 40 to 50 wt% of fluororesin is formed on the sliding contact surface (see patent document 2).

[0005] As described in paragraph 0020 of the patent document 1, the resin coating is formed by using coating methods such as a spray coating method, an electrostatic coating method, a screen printing method, a pad printing method, a roll method, a dipping method, and a tumbling method.

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0006]

Patent document 1: Japanese Patent Application Laid-Open Publication No. H11-013638
Patent document 2: Japanese Patent Application Laid-Open Publication No. 2009-209727

SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0007] To stabilize the friction and wear property of the above-described resin coating, it is necessary to increase accuracy such as the flatness degree thereof by subjecting the surface thereof to grinding processing after the resin coating is formed. But the resin coating of the swash plate formed by using a known coating method has a problem that it is difficult to process the resin coating with high accuracy by the grinding processing. For example, to subject a thin resin coating to the grinding processing with high accuracy, the base material constituting the ground of the swash plate should be processed with high accuracy. In more detail, after the base material is subjected to lathe turning, it is necessary to subject the base material to the grinding processing with high accuracy. For this reason, the process of manufacturing the swash plate is complicated and thus it is difficult to comply with a demand for a decrease in the manufacturing cost thereof.

[0008] In the case where the strength of adhesion between the resin coating and the base material of the swash plate is low, the resin coating peels off the base material when the resin coating is subjected to the grinding processing. Thus it is difficult to process the surface of the resin coating with high accuracy by the grinding processing.

[0009] In association with the trend of saving energy required to operate an entire apparatus and the trend of decreasing the weight and size thereof in recent years, the swash plate for the swash plate compressor is demanded to be excellent in its low friction property and wear resistance property and the strength of adhesion between the base material and the resin coating. The swash plate is also demanded to prevent the occurrence of seizing and erosion or the like caused by cavitation (shock property caused by rupture of generated bubbles).

[0010] The present invention has been made to deal with the above-described problems. Therefore it is an object of the present invention to provide a resin coating-provided swash plate, for a swash plate compressor,

manufactured in a manufacturing method which includes a process shorter than a process of a conventional coating method and which allows the resin coating to be subjected to grinding processing with high accuracy and to have a high strength of adhesion to a base material of the swash plate, a method for manufacturing the swash plate, and the swash plate compressor having the swash plate.

MEANS FOR SOLVING THE PROBLEM

[0011] The present invention provides a swash plate, for a swash plate compressor, so constructed that inside a housing where a refrigerant is present, a rotational motion of the swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing the swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to the rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on the swash plate to compress and expand the refrigerant, wherein a resin coating is formed on a sliding contact surface of the swash plate on which the shoe slides, and the resin coating has a layered structure in which a plurality of layers lie one upon another in a direction parallel with the sliding contact surface in an axial cross section thereof. The resin coating is formed by linearly applying resin paint discharged from a discharge port to a base material of the swash plate.

[0012] The resin coating is formed by applying the resin paint to the base material of the swash plate concentrically and circumferentially or spirally relative to the central axis of the swash plate. The resin paint is droplet-like.

[0013] A part of the base material of the swash plate which is to constitute a ground to be disposed directly under the resin coating is subjected to shot blast treatment. The base material of the swash plate consists of the steel plate disk-shaped by subjecting the rolled steel plate to pressing processing. Both surfaces of the disk-shaped steel plate are subjected to lathe turning processing and thereafter the shot blast treatment.

[0014] A surface of the resin coating is subjected to grinding processing by using a double head grinding machine

[0015] The resin coating contains matrix resin and at least fluororesin and graphite. The resin coating contains 25 to 70 parts by weight of the fluororesin and 1 to 20 parts by weight of the graphite for 100 parts by weight of the matrix resin. The tensile shear adhesive strength (conforming to JIS K6850) of the resin coating is set to not less than 25 MPa.

[0016] The present invention provides a method of for manufacturing a swash plate, for a swash plate compressor, so constructed that inside a housing where a refrigerant is present, a rotational motion of a swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing the swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to the rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on the swash plate to compress and expand the refrigerant. The manufacturing method has a coating-forming process for forming a resin coating on a sliding contact surface of the swash plate on which the shoe slides. In the coating-forming process, the resin coating is formed by linearly applying resin paint discharged from a discharge port to a base material of the swash plate.

[0017] Before the coating-forming process is performed, as a process for treating the base material of the swash plate, both surfaces of the base material consisting of a rolled steel plate disk-shaped by subjecting the rolled steel plate to pressing processing is subjected to lathe turning processing and thereafter a part of the base material of the swash plate which is to constitute a ground to be disposed directly under the resin coating is subjected to the shot blast treatment.

[0018] The present invention provides a swash plate compressor having a swash plate so constructed that inside a housing where a refrigerant is present, a rotational motion of a swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing the swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to the rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on the swash plate to compress and expand the refrigerant. As the swash plate, the swash plate of the present invention is used as the above-described swash plate.

EFFECT OF THE INVENTION

[0019] In the swash plate for the swash plate compressor of the present invention, the resin coating is formed on the sliding contact surface of the swash plate on which the shoe slides. The resin coating has a layered structure in which a plurality of the layers lie one upon another in the direction parallel with the sliding contact surface of the swash plate in the axial cross section of the resin coating. Therefore it is possible to prevent the resin coating from peeling off the sliding contact surface of the swash plate at interlaminar parts thereof when the shoe makes sliding contact with the resin coating. In addition, the resin coating is continuous in the direction in which the shoe makes the sliding contact with the resin coating. Thus the resin coating has an excellent property in sliding contact with the shoe. Because the resin coating is formed by linearly applying the resin paint discharged from the discharge port to the base material of the swash plate, the resin coating has a high strength of adhesion to the base material of the swash plate. Thus the resin coating does not peel off the base material in subjecting the resin coating to grinding processing, which allows the surface of the resin coating to be subjected to the grinding processing with high accuracy.

[0020] Because the resin coating is formed by applying the resin paint to the base material of the swash plate concentrically and circumferentially or spirally relative to

the central axis of the swash plate, it is easy to form the structure of the resin coating in which a plurality of the layers lie one upon another in the direction parallel with the sliding contact surface of the base material in the axial cross section of the resin coating. In addition, the continuous coating is formed along the direction in which the shoe makes the sliding contact with the resin coating. Therefore the resin coating has an excellent property in the sliding contact with the shoe. By spirally applying the resin paint, it is possible to apply the resin paint to the entire swash plate without a break and prevent the resin paint from being nonuniformly applied thereto. Therefore the resin coating has an extremely excellent property in the sliding contact with the shoe.

[0021] Because the resin paint is the droplet-like resin paint, the discharge pressure can be set higher than that set in continuously applying the resin paint to the base material of the swash plate. Thus the resin paint is applied to minute concavities and convexities present on the surface of the base material as though the resin paint cuts thereinto. Thus the resin coating is allowed to have a high strength of adhesion to the base material of the swash plate.

[0022] Because a part of the base material of the swash plate which is to constitute the ground to be disposed directly under the resin coating is subjected to the shot blast treatment, the base material is excellent in the strength of adhesion to the resin coating without forming an intermediate layer such as a metal-sprayed layer between the resin coating and the base material. Further it is possible to simplify the manufacture of the swash plate and thus decrease the manufacturing cost.

[0023] The base material of the swash plate consists of the steel plate disk-shaped by subjecting the rolled steel plate to pressing processing. Both surfaces of the disk-shaped steel plate are subjected to lathe turning processing and thereafter the shot blast treatment. Thereby it is possible to improve the strength of adhesion of the swash plate to the resin coating, which preferably affects the finishing accuracy of the swash plate. In addition, the method of the present invention eliminates the need for subjecting both surfaces of the steel plate to precision grinding to be carried out after both surfaces thereof are subjected to the lathe turning processing unlike a base material formed by using a conventional production method.

[0024] Because the surface of the resin coating is subjected to the grinding processing (finish processing) by using the double head grinding machine after the resin coating is formed by applying the resin paint to the base material of the swash plate, it is possible to adjust parallelism between both sliding contact surface of the swash plate with high accuracy.

[0025] Because the resin coating contains the matrix resin and at least the fluororesin and the graphite, the resin coating is excellent in its low friction property and wear resistance. The resin coating contains 25 to 70 parts by weight of the fluororesin and 1 to 20 parts by weight of the graphite for 100 parts by weight of the matrix resin. Because the tensile shear adhesive strength of the resin coating is not less than 25 MPa, the resin coating is excellent in its low friction property and its wear resistance. Because the resin coating has the high tensile shear adhesive strength, the resin coating has a high strength of adhesion to the base material of the swash plate. Therefore the swash plate is capable of enduring use without the resin coating peeling off the base material even in the case where a surface pressure applied to the swash plate is not less than 10 MPa. In addition, the resin coating has an excellent cavitation resistance and is thus capable of preventing cavitation-caused erosion in the presence of lubricating oil.

[0026] The method of the present invention for manufacturing the swash plate for the swash plate compressor has the coating-forming process for forming the resin coating on the sliding contact surface of the swash plate on which the shoe slides. In the coating-forming process, the resin coating is formed by linearly applying the resin paint discharged from the discharge port to the base material of the swash plate. Therefore the manufacturing method is capable of forming the resin coating excellent in the strength of adhesion to the base material of the swash plate. In addition, the manufacturing method is capable of improving the productivity and yield of the swash plate over a swash plate formed by adopting a conventional coating method such as a spray coating method. In addition, the manufacturing method allows a thick coating to be easily formed. Therefore it is unnecessary to process the base material of the swash plate with high accuracy and thus it is possible to shorten the process of manufacturing the swash plate. Consequently the manufacturing method allows the manufacturing cost to be lower than that of a method of manufacturing the swash plate by adopting a conventional coating method.

[0027] The swash plate compressor of the present invention has the swash plate having the above-described structure. Therefore the swash plate of the present invention can be manufactured at a cost lower than a swash plate formed by adopting a conventional coating method and yet has a sufficiently high strength of adhesion to the base material of the swash plate. In the case where a shoe having a small diameter locally contacts the swash plate, in the case where an inexpensive shoe which is made of SUJ2 or the like and is not specially treated is used, and in the case where the lubricating oil is depleted, the swash plate is excellent in its resistance to the occurrence of seizing and capable of avoiding a trouble caused by the seizing. Thus the swash plate compressor is stable and has a long life. In addition, because the swash plate can be operated at a high surface pressure, the swash plate can be suitably used for swash plate compressors to be operated by using carbon dioxide or HFC1234yf as a refrigerant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028]

Fig. 1 is a vertical sectional view showing an example of a swash plate compressor of the present invention.

Fig. 2 is a sectional view showing an enlarged swash plate shown in Fig. 1.

Fig. 3 is a partial cutaway side view of the swash plate shown in Fig. 1.

Fig. 4 shows a process of forming a resin coating.

Fig. 5 shows a process of forming a resin coating (droplet-like resin paint is used).

Fig. 6 is a partly enlarged view showing the structure of the resin coating.

MODE FOR CARRYING OUT THE INVENTION

[0029] One embodiment of the swash plate compressor of the present invention is described below with reference to the drawings. Fig. 1 is a vertical sectional view showing one example of the swash plate compressor of the present invention. In the swash plate compressor shown in Fig. 1, carbon dioxide is used as a refrigerant. The swash plate compressor is a double swash plate type and is so constructed that inside a housing 1 where the refrigerant is present, a rotational motion of a swash plate 3 mounted obliquely on a rotational shaft 2 by directly fixing the swash plate 3 to the rotational shaft 2 is converted into a reciprocating motion of double head type pistons 5 through a shoe 4 which slides on both side surfaces of the swash plate 3 to compress and expand the refrigerant at both sides of each of the double head type pistons 5 disposed inside a cylinder bore 6 at regular intervals in the circumferential direction of the housing 1. The rotational shaft 2 to be driven at a high speed is supported by a needle roller bearing 7 in its radial direction and by a thrust needle roller bearing 8 in its thrust direction.

[0030] The swash plate 3 may have a mode in which the swash plate 3 is indirectly fixed to the rotational shaft 2 via a coupling member. The swash plate 3 may also have a mode in which the swash plate 3 is mounted on the rotational shaft 2 not obliquely but perpendicularly thereto. The main characteristic of the swash plate for the swash plate compressor of the present invention is that a resin coating having a predetermined structure is formed on a sliding contact surface of the swash plate on which the shoe slides by carrying out a predetermined method of applying resin paint to the sliding contact surface. Therefore the swash plate of the present invention is applicable to the swash plate compressors having any of the above-described modes.

[0031] A concave portion 5a is formed on each piston 5 in such a way that the concave portion 5a strides over an outer peripheral portion of the swash plate 3. A semispherical shoe 4 is seated on a spherical seat 9 formed on a surface axially opposed to the concave portion 5a and supports the pistons 5 movably relative to the rotation of the swash plate 3. Thereby the rotational motion of the swash plate 3 can be smoothly converted into the reciprocating motions of the pistons 5. As necessary, the surface of the shoe 4 may be subjected to processing such as nickel plating or the like to improve the sliding property thereof.

[0032] As shown in Figs. 2 and 3, a base material 3a of the swash plate 3 consists of a rolled steel plate disk-shaped by subjecting the rolled steel plate to pressing processing. Both surfaces of the disk-shaped steel plate are subjected to lathe turning processing and thereafter shot blast treatment to form a resin coating 10 having a low friction property on both surfaces of the steel plate by carrying out a predetermined method described later. The shoe 4 makes sliding contact with both surfaces of the base material 3a (see Fig. 1).

[0033] The resin coating 10 is processed with high accuracy by carrying out grinding processing. By subjecting the resin coating 10 to the grinding processing by using a double head grinding machine, it is possible to adjust the parallelism between both surfaces of the swash plate with high accuracy. As a grinding processing method to be carried out by using the double head grinding machine, it is possible to adopt a drive-type double head grinding method of simultaneously grinding the upper and lower surfaces, of the disk-shaped steel plate, which are the sliding contact surfaces with a grinding stone while the disk-shaped steel plate is being rotated with its axis being held. The grinding processing allows the flatness degree of the surfaces of the swash plate to be high.

[0034] A part of the base material of the swash plate which is to constitute a ground to be disposed directly under the resin coating is subjected to the shot blast treatment to form the base material 3a. Thereby the base material is excellent in the strength of adhesion to the resin coating without forming an intermediate layer such as a metal-sprayed layer between the resin coating and base material. In addition, the resin coating peels off the base material to a much lesser extent. Further, non-formation of the sprayed metal layer leads to a decrease in the manufacturing cost of the swash plate and prevents the deterioration of the flatness degree thereof.

[0035] The structure of the resin coating 10 is described below with reference to Fig. 6. Fig. 6 (a) is a sectional view (partly enlarged) of the resin coating in its axial direction. Fig. 6 (b) is a plan view (partly enlarged) of the resin coating. As shown in Fig. 6(a), the resin coating 10 has a layered structure in which a plurality of layers lie one upon another in a direction (shown by an arrow A in Fig. 6(a)) parallel with a sliding contact surface 3b in the axial cross section thereof. That is, interlaminar parts 10a are almost vertical to the sliding contact surface 3b. From the property of the resin paint, the "layered structure" includes a case in which there is a portion where adjacent layers are completely integrated with each other in the neighborhood of the sliding contact sur-

face. In the case where a multi-layered coating consisting of a plurality of layers layered one upon another in the direction vertical to the sliding contact surface 3b is formed, there is a concern that the resin coating peels off the sliding contact surface 3b at the interlaminar parts when the shoe makes the sliding contact with the resin coating. But the above-described structure of the resin coating of the present invention is capable of eliminating the concern. As shown in Fig. 6(b), the interlaminar parts 10a of the resin coating 10 are formed along the direction (shown with an arrow B of Fig. 6(b)) in which the shoe makes the sliding contact with the resin coating. Therefore the resin coating has an excellent property in the sliding contact with the shoe.

[0036] It is preferable that the resin coating 10 contains matrix resin and at least fluororesin and graphite. In more detail, it is preferable that the resin coating 10 contains 25 to 70 parts by weight of the fluororesin and 1 to 20 parts by weight of the graphite for 100 parts by weight of the matrix resin and has a tensile shear adhesive strength (conforming to JIS K6850) not less than 25 MPa (preferably not less than 30 MPa). In the case where the resin coating having the above-described composition is formed on the swash plate, the swash plate 3 can be used without the resin coating peeling off the swash plate 3 even in the case where a surface pressure applied to the swash plate is not less than 10 MPa. Thus the resin coating is capable of satisfying its low friction property, wear-resistant property, strength of adhesion to the base material of the swash plate, and cavitation resistance in the presence of lubricating oil in a favorable balance.

[0037] As the matrix resin, it is possible to use heat-resistant resins which do not thermally deteriorate when the swash plate is in use and allow fluororesin powders to bind with one another and the resin coating to firmly adhere to the base material of the swash plate. Examples of the matrix resin include polyphenylene sulfide resin, polyether ether ketone resin, polyimide resin, polyamide resin, polyamide imide (PAI) resin, epoxy resin, and phenol resin. Of these matrix resins, it is preferable to use the PAI resin because the PAI resin is excellent in its heat resistance and wear-resistant property and allows the resin coating to have excellent adhesion to the base material of the swash plate.

[0038] The PAI resin has an imide bond and an amide bond in its polymeric main chain. Of the PAI resins, aromatic PAI resin in which the imide bond and the amide bond are bonded to each other via an aromatic group is preferable. In the case where the aromatic PAI resin is used as the matrix resin, the obtained resin coating containing the PAI resin is excellent in its property of binding with the base material which constitutes the ground of the swash plate and is especially excellent in its heat resistance. The imide bond of the aromatic PAI resin may be a precursor such as polyamide acid, a ring-closed imide ring or have a state in which the precursor and the ring-closed imide ring are mixed with each other.

[0039] Examples of the aromatic PAI resin include PAI resin to be produced from aromatic primary diamine, for example, diphenylmethane diamine and aromatic tribasic acid anhydride, for example, mono or diacyl halide derivative of trimellitic acid anhydride, and from the aromatic tribasic acid anhydride and an aromatic diisocyanate compound, for example, diphenylmethane diisocyanate. In addition, examples of the PAI resin having the imide bond at a higher ratio than the amide bond include PAI resins produced from an aromatic compound, an aliphatic compound or an alicyclic diisocyanate compound, an aromatic tetrabasic acid dianhydride, and an aromatic tribasic acid anhydride. Any of the above-described PAI resins can be used.

[0040] It is possible to use fluororesins which have a low friction, are capable of imparting unadhesiveness to the resin coating, and are heat-resistant to such an extent that they are capable of withstanding an air temperature at which the swash plate is used. Examples of the fluororesin include polytetrafluoroethylene (PTFE) resin, tetrafluoroethylene-perfluoroalkyl vinyl ether (PFA) copolymer resin, tetrafluoroethylene-hexafluoropropylene (FEP) copolymer resin, and tetrafluoroethylene-ethylene (ETFE) copolymer resin. Of these fluororesins, it is preferable to use PTFE resin powder. The PTFE resin is as high as 10^{10} to 10^{11} Pa·s in its melt viscosity at 340°C to 380°C, is unlikely to flow at temperatures higher than its melting point, is most heat-resistant of all fluororesins, shows excellent properties even at low temperatures, and is excellent in its friction and wear property.

[0041] As the PTFE resin, it is possible to use PTFE resin, commonly used, which is shown by $-(CF_2-CF_2)_n-$. It is also possible to use modified PTFE resin composed of the commonly used PTFE resin into which a perfluoroalkyl ether group (C_pF_{2p}-O-) (p is integers of 1 through 4) or a polyfluoroalkyl group ($H(CF_2)_q$-) (q is integers of 1 to 20) is introduced. It is possible to use the PTFE resin and the modified PTFE resin obtained by adopting commonly used methods such as a suspension polymerization method of obtaining molding powder and an emulsification polymerization method of obtaining fine powder.

[0042] The average particle diameter (value measured by laser analysis method) of the PTFE resin powder is not specifically limited, but it is preferable to set it to not more than 30μm to keep the surface smoothness of the resin coating.

[0043] It is possible to use the PTFE resin powder obtained by heating and calcining the PTFE resin at temperatures not less than its melting point. It is also possible to use the PTFE resin powder obtained by irradiating the heated and calcined powder with y rays or electron rays. The heated and calcined PTFE resin powder is superior to the PTFE resin powder (molding powder, fine powder) not heated nor calcined because the former disperses in the resin paint which forms the resin coating more uniformly than the latter and allows the resin coating containing the former to be superior to the resin coating containing the latter in its wear-resistant property.

[0044] It is preferable to mix 25 to 70 parts by weight of the fluororesin such as the PTFE resin for 100 parts by weight of the matrix resin of the resin coating. When the mixing amount of the fluororesin is less than 25 parts by weight, there is a fear that the resin coating is inferior in its low friction property and that wear is accelerated by generated heat. Moreover, workability in coating the base material of the swash plate with the resin coating is low. On the other hand, when the mixing amount of the fluororesin exceeds 70 parts by weight, the resin coating is superior in its low friction property, but has a low strength and a low wear resistance. Thus under an extreme pressure generated when the shoe makes a partial sliding contact with the swash plate, there is a fear that abnormal wear occurs. When the mixing amount of the fluororesin is set to 40 to 50 parts by weight, the tensile shear adhesive strength of the resin coating exceeds 35 MPa. Thus it is possible to secure a safety rate in the condition in which the extreme pressure is generated when the shoe makes the partial sliding contact with the swash plate. That the mixing amount of the fluororesin exceeds 70 parts by weight for 100 parts by weight of the matrix resin means a case in which when the mixing amount of the fluororesin is converted into the content of the fluororesin contained in the resin coating, the mixing amount thereof exceeds about 40 wt%.

[0045] It is well known that the graphite has an excellent property as a solid lubricant and is used as the solid lubricant for the swash plate. The graphite is classified into natural graphite and artificial graphite. As the configuration of the graphite, there exist a flaky shape, a granular shape, and a spherical shape. It is possible to use the graphite having any of the above-described shapes. It is considered that the artificial graphite is unsuitable as a lubricant because its lubricating performance is inhibited by carborundum generated during a production step and because it is difficult to produce graphite having a high degree of graphitization. Because the natural graphite completely graphitized is yielded, it has a very high lubricating property and is thus suitable as the solid lubricant. But the natural graphite contains a large amount of impurities which deteriorate its lubricating property. Although it is necessary to remove the impurities, it is difficult to completely remove them.

[0046] It is favorable to use graphite composed of not less than 97.5% of fixed carbon and more favorable to use artificial graphite composed of not less than 98.5% of the fixed carbon. The above-described graphite and artificial graphite have an affinity for the lubricating oil. Thus even though the graphite does not have the lubricating oil attaching to the surface thereof, its lubricating property is maintained by a slight amount of the lubricating oil impregnated thereinto.

[0047] It is preferable to mix 1 to 20 parts by weight of the graphite with 100 parts by weight of the matrix resin of the resin coating to modify the friction and wear property of the resin coating. When the mixing amount of the graphite is less than one part by weight, the effect of modifying the friction and wear property of the resin coating cannot be obtained, even though the graphite is added to the matrix resin. On the other hand, when the mixing amount of the graphite exceeds 20 parts by weight, there is a fear that the graphite impairs the adhesion of the resin coating to the base material of the swash plate and that the resin coating peels off the base material of the swash plate. When the total of the addition amount of the additives including the fluororesin, the graphite, and other additives is less than 15 parts by weight for 100 parts by weight of the matrix resin, the resin coating is nonuniform in its thickness. Thus it is difficult to obtain a required dimensional accuracy.

[0048] In addition to the matrix resin, the fluororesin, and the graphite, the resin coating may contain other additives in a range in which they do not outstandingly deteriorate the necessary properties of the swash plate of the present invention. In the case where the resin coating is formed of three components, namely, the matrix resin, the fluororesin, and the graphite, the resin coating is capable of obtaining its tensile shear adhesive strength, low friction property, wear resistance, and the cavitation resistance in the most favorable balance.

[0049] In the case where the PAI resin is used as the matrix resin of the resin coating, the PTFE resin is used as the fluororesin, and the graphite composed of not less than 97.5% of the fixed carbon is used, these resins and the graphite are easily obtainable and comparatively inexpensive, which leads to a decrease in the cost of the swash plate.

[0050] Because the compressor has become lightweight and compact recently, the swash plate is required to be compact and operated at a high speed and under a high load to maintain a high output. Because in an operation performed at a high speed and under a high load in the presence of the lubricating oil, the cavitation is liable to occur. Thus the resin coating is demanded to have the cavitation resistance to prevent the occurrence of the cavitation-caused erosion. To keep the cavitation resistance of the resin coating, it is necessary to increase the mixing ratio of the PAI resin to be used as the matrix resin to that of the solid lubricant. When the mixing amount of the fluororesin exceeds 70 parts by weight, the mixing ratio of the matrix resin playing the roll of a binder becomes low. Thereby the cavitation resistance of the resin coating is insufficient. When the total of the addition amounts of the additives including the fluororesin, the graphite, and other additives for 100 parts by weight of the matrix resin exceeds 90 parts by weight, the cavitation-caused erosion of the resin coating is liable to occur. On the other hand, by setting the total of the addition amounts of the above-described components to not more than 90 parts by weight, the cavitation resistance of the resin coating is secured, which is desirable.

[0051] The method of the present invention for manufacturing the swash plate for the swash plate compressor is characterized in that the method has a coating-forming process for forming the resin coating on the sliding con-

tact surface of the swash plate on which the shoe slides and that in the coating-forming process, the coating is formed by linearly applying the resin paint discharged from the discharge port to the base material of the swash plate.

[0052] The method for forming the resin coating 10 is described below with reference to Figs. 4 and 5. Fig. 4 shows a case in which the resin paint is continuously discharged. Fig. 5 shows a case in which the resin paint is droplet-like. Like resin paint 12 of Fig. 5, the droplet-like resin paint consists of droplets intermittently continuous and is distinguished from resin paint continuously discharged like the resin paint 12 of Fig. 4. In Figs. 4 and 5, the resin coating 10 is formed by linearly applying the resin paint 12 discharged from a discharge port 11 of a quantitative liquid discharge apparatus to the base material 3a of the swash plate 3. Linearly applying the resin paint means that while the resin paint 12 is being discharged from the discharge port 11, the discharge port 11 is moved relative to the base material 3a to form a continuous portion having a certain width corresponding to the size of the discharge port. As a method of moving the discharge port 11 relative to the base material 3a, the base material 3a may be moved relative to the discharge port 11 with the base material 3a set on an X-Y table or vice versa. Alternatively both the discharge port 11 and the base material 3a may be moved. A needle nozzle is mainly used as the discharge port. As the configuration of the discharge port, a round configuration, a flat configuration, and a rectangular configuration are used. By applying the resin paint to the sliding contact surface of the base material 3a linearly and without a break, the base material 3a is not exposed in the sliding contact surface.

[0053] As a method of applying the resin paint 12 to the sliding contact surface of the base material 3a linearly and without a break, it is possible to adopt (1) a method of applying the resin paint to the base material of the swash plate concentrically and circumferentially relative to the central axis of the swash plate and (2) a method of applying the resin paint spirally relative to the central axis thereof. Application of the resin paint to the base material by carrying out the above-described methods allows the resin coating having the structure shown in Fig. 6 to be easily and continuously formed along the direction in which the shoe makes the sliding contact with the resin coating. Thus the resin coating has an excellent property in the sliding contact with the shoe. The method (2) allows the resin paint to be applied to the entire base material of the swash plate without a break and prevents the resin paint to be nonuniformly applied thereto. Therefore the resin coating formed by using the method (2) has an extremely excellent property in the sliding contact with the shoe. In addition, it is possible to form the resin coating by linearly applying the resin paint 12 to the base material of the swash plate. In this case, the surface of the swash plate can be grinded with high accuracy by subjecting the surface of the swash plate to surface grinding in conformity to a direction in which the resin paint 12 is applied to the base material.

[0054] The resin paint is obtained by dispersing or dissolving the matrix resin, the fluororesin, and the graphite all of which are solid contents in a solvent at a predetermined mixing ratio. The resin paint is discharged continuously or dropwise by using the quantitative liquid discharge apparatus. As solvents, it is possible to use ketones such as acetone, methyl ethyl ketone; esters such as methyl acetate and ethyl acetate; aromatic hydrocarbons such as toluene and xylene; organic halogen compounds such as methylchloroform, trichloroethylene, and trichlorotrifluoroethane; and non-proton type polar solvents such as N-methyl-2-pyrrolidone (NMP), methylisopyrrolidone (MIP), dimethylformamide (DMF), and dimethylacetamide (DMAC). These solvents can be used singly or as a mixture. It is preferable to adjust the viscosity of the resin paint to 1000 to 10000 mPa·s.

[0055] In the method of the present invention, because the resin paint is applied to the base material of the swash plate by discharging the resin paint at the predetermined discharge pressure, the method is capable of improving the productivity and yield of the swash plate over a swash plate formed by adopting a conventional coating method such as a spray coating method. Particularly the method of the present invention allows the resin paint to be used less wastefully and a thick coating to be formed in a shorter period of time than the spray coating method. Even though the accuracy of the flatness degree of the base material is low, the thick resin coating compensates for the low flatness degree thereof. Thus it is possible to secure the flatness degree of the surface of the base material, which makes it unnecessary to process the base material of the swash plate with high accuracy. The resin coating formed by adopting the conventional spray coating method is thin. Thus after both surfaces of the base material are subjected to the lathe turning processing, it is necessary to subject both surfaces thereof to the grinding processing with high accuracy. On the other hand, the method of the present invention eliminates the need for subjecting the base material to the grinding processing after it is subjected to the lathe turning processing. Consequently it is possible to shorten the process of manufacturing the swash plate and decrease its manufacturing cost.

[0056] As shown in Fig. 5, in the case where the droplet-like resin paint is applied to the base material of the swash plate by discharging it at the predetermined discharge pressure and bringing it into contact with the base material, the resin paint is allowed to easily penetrate into minute concavities and convexities of the surface of the base material. Thus the strength of adhesion between the base material of the swash plate and the resin coating is allowed to be higher. Therefore the resin coating does not peel off the base material in the grinding processing of the resin coating and can be grinded with high accuracy.

[0057] By linearly applying the resin paint to the base

material of the swash plate and thereafter burning the resin paint, it is possible to obtain the resin coating which has hardened and attached firmly to the base material. The thickness of the burnt resin coating is set to 40μm to 60μm. The resin coating having a thickness of 40μm to 60μm is processed by using the double head grinding machine to set its thickness to 8μm to 30μm and both its flatness degree and parallelism to not more than 15μm as the final finish accuracy. Because the resin coating is subjected to the grinding processing (finish processing) by using the double head grinding machine, it is possible to adjust the parallelism between both sliding contact surfaces of the swash plate with high accuracy. In the present invention, the flatness degree and the parallelism are defined in JIS B0182.

[0058] The surface roughness of the resin coating can be altered according to the count of a grinding stone. It is favorable to set its surface roughness to 0.1 to 1.0 μmRa. By setting its surface roughness to this range, there is an increase in the real contact area of the sliding contact surface of the resin coating on which the shoe slides. Thus it is possible to decrease an actual contact pressure and prevent the occurrence of seizing. When the surface roughness of the resin coating is less than 0.1 μmRa, the lubricating oil is insufficiently supplied to the sliding contact surface. When the surface roughness of the resin coating exceeds 1.0 μmRa, the real contact area of the sliding contact surface becomes small. As a result, a high contact pressure is locally applied to the sliding contact surface and thus there is a fear that the seizing occurs. It is more favorable to set the surface roughness of the resin coating to 0.2 to 0.8 μmRa. In the present invention, the surface roughness Ra is defined in JIS B0601.

[0059] In the case where a part of the base material of the swash plate which is to constitute the ground to be disposed directly under the resin coating is subjected to the grinding processing after the disk-shaped steel plate is subjected to the lathe turning, the base material is allowed to have a high flatness degree. Thereby the resin coating has a uniform thickness securely, and lubricating oil allows a stable boundary-lubrication state to be achieved between it and the resin coating. Thus even when the lubricating oil is exhausted, it is possible to stabilize the friction and wear property of the resin coating with the boundary between the base material and the resin coating being lubricated.

[0060] The swash plate compressor of the present invention has the swash plate having the above-described structure. Therefore even in the case where a shoe having a small diameter locally contacts the swash plate, in the case where an inexpensive shoe which is made of SUJ2 or the like and is not specially treated is used, and in the case where the lubricating oil is depleted, the swash plate is excellent in its resistance to the occurrence of the seizing. In addition, it is possible to prevent the cavitation-caused erosion of the resin coating when the swash plate is operated at a high surface pressure and a high speed in the presence of the lubricating oil. Further it is possible to decrease the manufacturing cost of the swash plate.

INDUSTRIAL APPLICABILITY

[0061] The swash plate for the swash plate compressor is manufactured in the manufacturing method which includes the process shorter than a process of a conventional coating method. The resin coating formed on the sliding contact surface can be subjected to the grinding processing with high accuracy and has a high strength of adhesion to the base material of the swash plate. Therefore the swash plate of the present invention can be preferably utilized for recently developed swash plate compressors operated at a high speed and under a high load by using carbon dioxide or the like as a refrigerant.

EXPLANATION OF REFERENCE NUMERALS AND SYMBOLS

[0062]

1:	housing
2:	rotational shaft
3:	swash plate
3a:	base material
3b:	sliding contact surface
4:	shoe
5:	piston
5a:	concave portion
6:	cylinder bore
7:	needle roller bearing
8:	thrust needle roller bearing
9:	spherical seat
10:	resin coating
10a:	interlaminar part
11:	discharge port
12:	resin paint

Claims

1. A swash plate for a swash plate compressor so constructed that inside a housing where a refrigerant is present, a rotational motion of said swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing said swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to said rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on said swash plate to compress and expand said refrigerant,
wherein a resin coating is formed on a sliding contact surface of said swash plate on which said shoe slides; and
said resin coating has a layered structure in which a plurality of layers lie one upon another in a direction

parallel with said sliding contact surface in an axial cross section thereof.

2. A swash plate for a swash plate compressor according to claim 1, wherein said resin coating is formed by linearly applying resin paint discharged from a discharge port to a base material of said swash plate.

3. A swash plate for a swash plate compressor according to claim 2, wherein said resin coating is formed by applying said resin paint to said base material of said swash plate concentrically and circumferentially or spirally relative to a central axis of said swash plate.

4. A swash plate for a swash plate compressor according to claim 2, wherein said resin paint is droplet-like.

5. A swash plate for a swash plate compressor according to claim 1, wherein a part of said base material of said swash plate which is to constitute a ground to be disposed directly under said resin coating is subjected to shot blast treatment.

6. A swash plate for a swash plate compressor according to claim 5, wherein said base material of said swash plate consists of a rolled steel plate disk-shaped by subjecting said steel plate to pressing processing; and both surfaces of said disk-shaped steel plate are subjected to lathe turning processing and thereafter said shot blast treatment.

7. A swash plate for a swash plate compressor according to claim 1, wherein a surface of said resin coating is subjected to grinding processing by using a double head grinding machine.

8. A swash plate for a swash plate compressor according to claim 1, wherein said resin coating contains matrix resin and at least fluororesin and graphite.

9. A method for manufacturing a swash plate for a swash plate compressor so constructed that inside a housing where a refrigerant is present, a rotational motion of a swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing said swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to said rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on said swash plate to compress and expand said refrigerant,
said method has a coating-forming process for forming a resin coating on a sliding contact surface of said swash plate on which said shoe slides; and
in said coating-forming process, said resin coating is formed by linearly applying resin paint discharged from a discharge port to a base material of said swash plate.

10. A method for manufacturing a swash plate for a swash plate compressor according to claim 9, wherein before said coating-forming process is performed, as a process for treating said base material of said swash plate, both surfaces of said base material consisting of a rolled steel plate disk-shaped by subjecting said rolled steel plate to pressing processing is subjected to lathe turning processing and thereafter a part of said base material of said swash plate which is to constitute a ground to be disposed directly under said resin coating is subjected to shot blast treatment.

11. A swash plate compressor having a swash plate so constructed that inside a housing where a refrigerant is present, a rotational motion of a swash plate mounted perpendicularly and obliquely on a rotational shaft by directly fixing said swash plate thereto or indirectly fixing the swash plate thereto through a coupling member to said rotational shaft is converted into a reciprocating motion of a piston through a shoe which slides on said swash plate to compress and expand said refrigerant, wherein said swash plate is as claimed in claim 1.

Fig.1

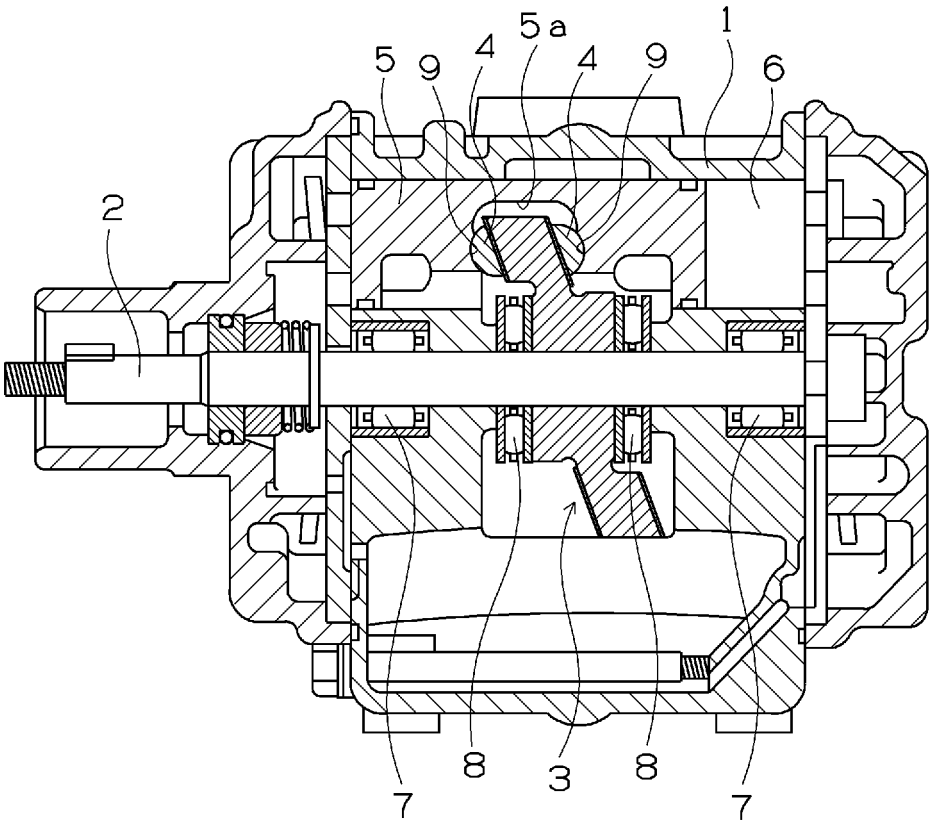


Fig.2

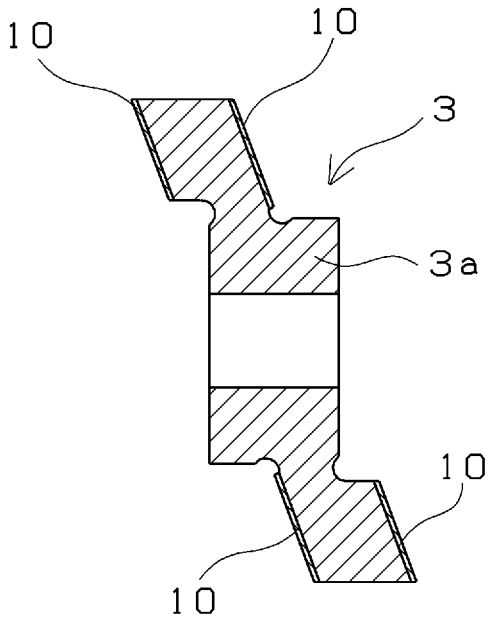


Fig.3

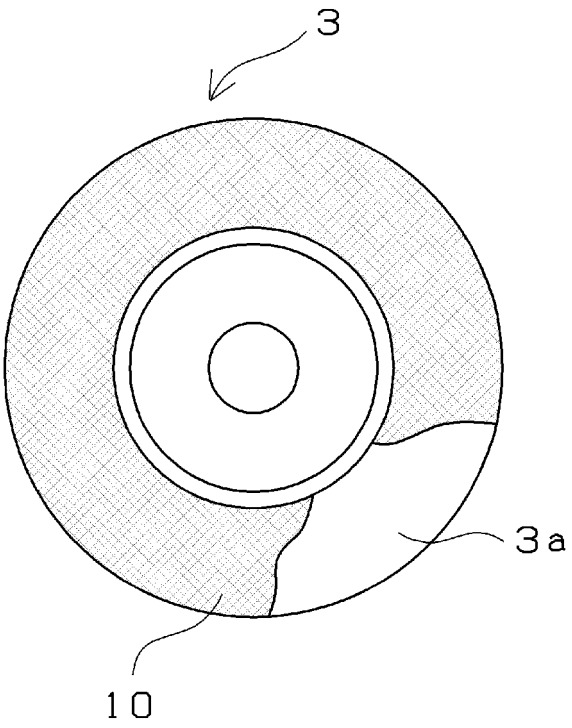


Fig.4

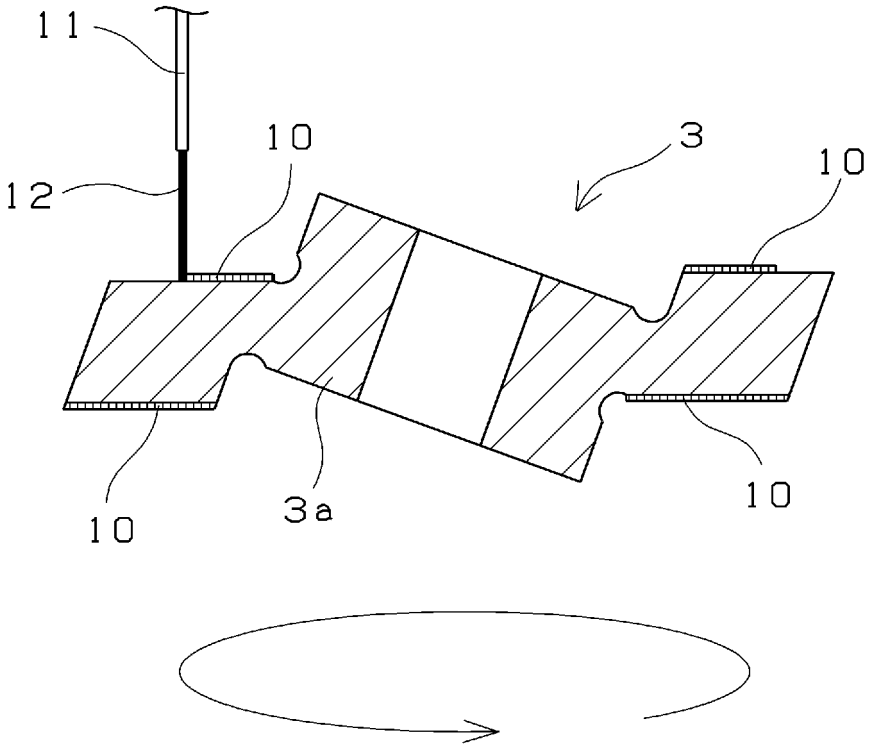


Fig.5

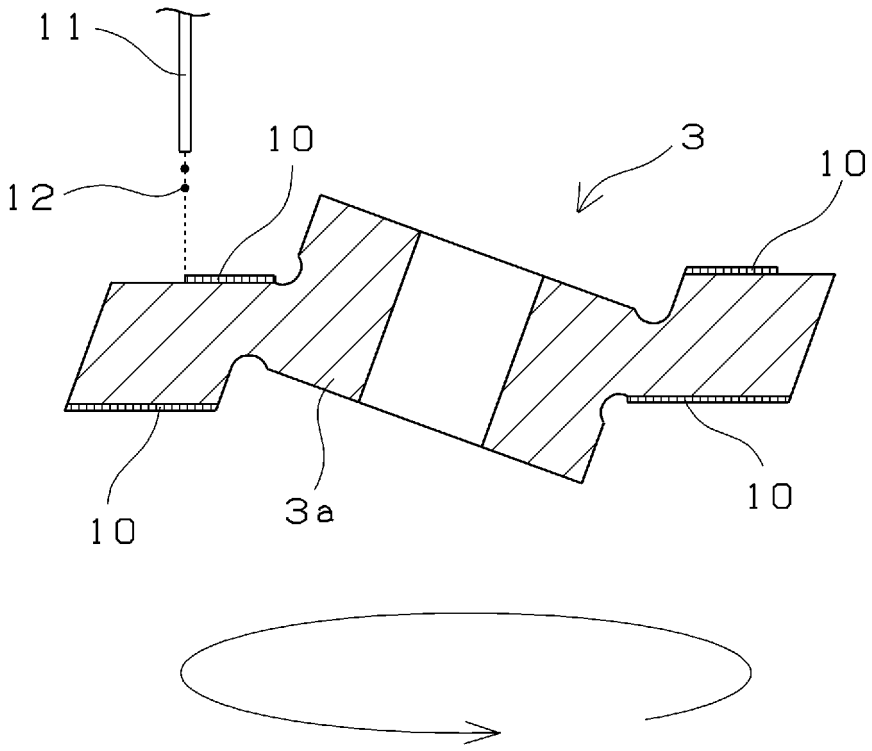
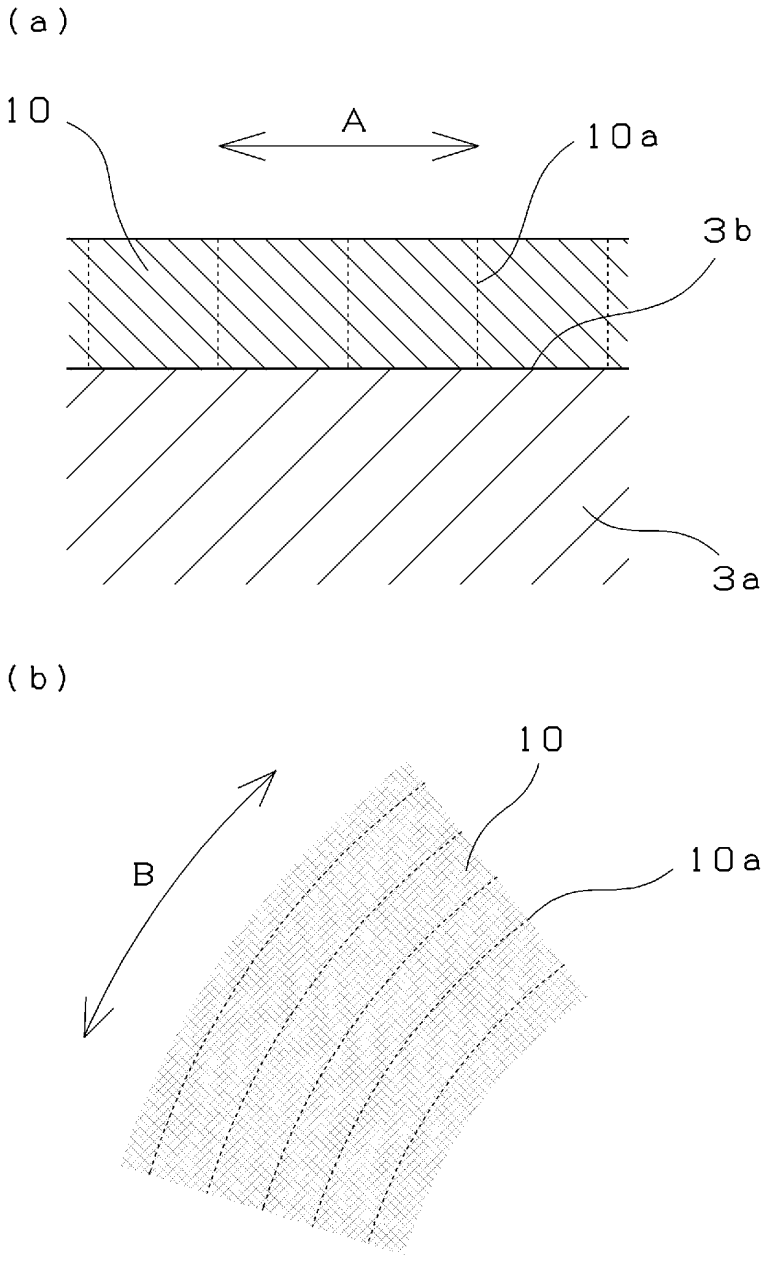


Fig.6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/065349

A. CLASSIFICATION OF SUBJECT MATTER
F04B27/08(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B27/08

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-205335 A (NTN Corp.), 16 August 2007 (16.08.2007), claims; paragraph [0005] & DE 102006037504 A1 & KR 10-2007-0026144 A	1-11
Y	JP 2010-223288 A (Toyota Central Research and Development Laboratories, Inc.), 07 October 2010 (07.10.2010), paragraph [0015] (Family: none)	1-11
Y	JP 2012-92822 A (NTN Corp.), 17 May 2012 (17.05.2012), claims & WO 2012/043336 A1	5-8,10

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 June, 2013 (14.06.13)	25 June, 2013 (25.06.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/065349

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2002-21719 A (Toyota Industries Corp.), 23 January 2002 (23.01.2002), paragraph [0003] (Family: none)	1-11
A	JP 2001-20856 A (Taiho Kogyo Co., Ltd.), 23 January 2001 (23.01.2001), paragraph [0025] & EP 001118768 A1 & US 6541127 B	6

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H11013638 B **[0006]**
- JP 2009209727 A **[0006]**