A method for assembling a bearing structure is provided. The bearing structure includes a housing of a cylindrical shape with one closed end, made up of a cylindrical portion and a cap portion. The method includes the steps of inserting a shaft integrated with a rotor hub into a sleeve and fixing a stopper member to the distal end of the shaft so as to make a hub assembly, inserting the sleeve into the housing, exerting a force on the sleeve to move toward the bottom of the housing until an end surface of the sleeve abuts the stopper member, pulling one of the housing and the hub assembly from the other relatively in the axial direction by a predetermined distance, and fixing the sleeve to the housing.
(a)  

(b)  

(c)  

(d)  

(e)  

fixing  

(baking in the curing oven)  

Fig. 3
Fig. 4
Fig. 6
Fig. 7
METHOD FOR ASSEMBLING BEARING OF SPINDLE MOTOR

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a method for assembling a bearing of a spindle motor that is used for driving a recording medium such as a hard disk.

[0003] 2. Description of the Prior Art

[0004] A bearing structure utilizing fluid dynamic pressure has become a mainstream as a bearing of a spindle motor for driving and rotating a recording medium in a hard disk driving device or a removable disk driving device. A fluid dynamic pressure bearing, e.g., a radial fluid dynamic pressure bearing has a structure in which lubricating oil as a fluid is filled in a gap between a shaft and a sleeve, and a pressure of the fluid (dynamic pressure) is generated when the shaft rotates. In addition, it is also common to adopt a thrust fluid dynamic pressure bearing as a thrust bearing in the axis direction, in which lubricating oil is filled in a gap between a stator and a rotor in the axis direction, and a dynamic pressure is generated when the shaft rotates.

[0005] In addition, miniaturization of a spindle motor has been realized along with downsizing of a hard disk driving device or the like. As a bearing structure of the spindle motor, one-piece design of the shaft and the rotor hub has been proposed and studied to make products. FIG. 8 shows an example of a miniaturized spindle motor. Its bearing includes a housing that has a cylindrical shape with one closed end made up of a cylindrical member 101 and a cap member 102 combined with each other, a sleeve 103 having a hollow cylindrical shape fixed to the inner surface of the cylindrical member 101, a shaft 104 disposed inside the sleeve 103 in a rotatable manner, a rotor hub 105 having substantially a disk shape formed integrally with the shaft 104 and connected to the proximal end of the shaft 104 at the middle portion, and a stopper member 106 fixed to the distal end of the shaft so as to be positioned at the bottom side of the housing.

[0006] A radial gap is formed between the sleeve 103 and the shaft 104, while an axial gap is formed between an opening end surface of the housing and the rotor hub 105 as well as between a stopper member 106 and an end surface of the sleeve 103. A space including these gaps is filled with lubricating oil (fluid).

[0007] The outer surface of the shaft 104 or the inner surface of the sleeve 103 is provided with grooves for gathering lubricating oil arranged in the rotation direction (for example, a plurality of herringbone grooves having a doglegged shape). These grooves make up a structure for generating a dynamic pressure of the lubricating oil when the shaft 104 rotates (i.e., a radial fluid dynamic pressure bearing 109). Two radial fluid dynamic pressure bearings 109 are disposed separately in the axial direction.

[0008] In addition, a first thrust fluid dynamic pressure bearing 111 is formed between the opening end surface of the housing and the rotor hub 105 for generating a dynamic pressure of the lubricating oil by similar grooves. A second thrust fluid dynamic pressure bearing 112 is formed between the stopper member 106 and the end surface of the sleeve 103 for generating a dynamic pressure of the lubricating oil by similar grooves. There are various forms and combinations that can be adopted as the fluid dynamic pressure bearing. There is a case where only the radial fluid dynamic pressure bearing 109 is provided. In another case, the radial fluid dynamic pressure bearing 109 and one of the thrust fluid dynamic pressure bearings 111 and 112 are provided. In still another case, each of the upper and the lower sides of the stopper member 106 is provided with the thrust fluid dynamic pressure bearing.

[0009] The bearing has the structure described above. The bearing of the housing 103 is assembled in the following manner. First, the sleeve 103 is inserted in the cylindrical member 101 of the housing, and the sleeve 103 is fixed to the inner surface of the cylindrical member 101 by adhesive or other means. In this step, a tool is used for precise registration between the cylindrical member 101 and the sleeve 103 in the axial direction. This registration is important for securing an appropriate axial gap between the stopper member 106 and the end surface of the sleeve 103 when the axial gap between the opening end surface of the housing and the rotor hub 105 is adjusted appropriately.

[0010] Next, the shaft 104 integrated with the rotor hub 105 is inserted in the sleeve 103, and the stopper member 106 is fixed to the distal end of the shaft 104. For example, an external thread formed on the outer surface of a shank portion of the stopper member 106 engages an internal thread formed on the inner surface of the shaft 104 at the distal end so that they are fixed precisely. Finally, the cap member 102 is fixed to the cylindrical member 101 and they are sealed by laser welding or other means so that a housing of a cylindrical shape with one closed end is made up of the cylindrical member 101 and the cap member 102. Then, lubricating oil is filled in a space that includes a radial gap between the sleeve 103 and the shaft 104, an axial gap between the opening end surface of the housing and the rotor hub 105, and an axial gap between the stopper member 106 and the sleeve 103.

[0011] The above-mentioned conventional bearing structure of the spindle motor adopts the shaft and the rotor hub that are integrated as one member. For the purpose of precise registration of the housing (the cylindrical member 101) and the sleeve 103 in the axial direction, it is necessary to assemble them in the following order. The cylindrical member 101 must be fixed to the sleeve 103 first by using a tool. After the shaft 104 is inserted in the sleeve 103, the stopper member 106 is fixed to the shaft 104. Then, the cap member 102 is sealed to the cylindrical member 101. Therefore, the housing of the cylindrical shape with one closed end (like a cup) must be made up of two separate members, i.e., the cylindrical member 101 and the cap member 102.

[0012] However, the structure of the housing made up of two separate members that are the cylindrical member 101 and the cap member 102 is disadvantageous in cost and administration because of its increased number of components compared with the housing of a cup shape in which the cylindrical member and the cap member are integrated. In addition, facilities and steps of laser welding or bonding are necessary for sealing the cylindrical member 101 with the cap member 102 in the assembly process. Moreover, if the sealed state (sealed state) of the cylindrical member 101 with the cap member 102 is incomplete, lubricating oil may
leak from the incomplete portion. Therefore, an inspection step such as a helium leak test is necessary for checking the sealed state of the seamed portion.

SUMMARY OF THE INVENTION

[0013] An object of the present invention is to provide a method for assembling a bearing having a novel structure including a component of integrated rotor hub and shaft and a housing of a cylindrical shape with one closed end made up of integrated cylindrical portion and cap portion.

[0014] A bearing structure of a spindle motor according to the present invention includes a housing of a cylindrical shape with one closed end, made up of a cylindrical portion and a cap portion for closing one end of the cylindrical portion, a sleeve of a hollow cylindrical shape fixed to the inner surface of the housing, a shaft inserted in the sleeve in a rotatable manner, a rotor hub having substantially a disk shape formed integrally with the shaft and connected to the proximal end of the shaft at the middle portion, and a stopper member fixed to the distal end of the shaft so as to be positioned at the bottom side of the housing, in which a radial gap is formed between the sleeve and the shaft, and an axial gap is formed between the opening end surface of the housing and the rotor hub as well as between the stopper member and an end surface of the sleeve.

[0015] According to this structure, the housing of a cylindrical shape with one closed end can be formed as one body of component by press molding, for example, which is advantageous in cost and administration compared with the conventional housing made up of the cylindrical member and the cap member. In addition, it is not necessary to seam the cylindrical member with the cap member in the assembling process, and an inspection step for checking a sealed state of the seamed part is not necessary too, unlike the conventional structure.

[0016] A method according to the present invention for assembling the bearing having the above-described structure includes the steps of (a) inserting the shaft integrated with the rotor hub into the sleeve and fixing the stopper member to the distal end of the shaft so as to make a hub assembly, (b) inserting the sleeve into the housing, (c) exerting a force on the sleeve to move toward the bottom of the housing until an end surface of the sleeve abuts the stopper member, (d) pulling one of the housing and the hub assembly from the other relatively in the axial direction by a predetermined distance, and (e) fixing the sleeve to the housing.

[0017] According to this method, a distance of separating the housing from the hub assembly in the step (d) can be controlled precisely. Therefore, high accuracy of at least the axial gap between the stopper member and an end surface of the sleeve can be secured.

[0018] In addition, the assembling method of the present invention is applied preferably to a bearing structure in which the housing is formed to have a wall thickness that is thinner at the cap portion than at the cylindrical portion. If the housing of a cylindrical shape with one closed end is formed by a press molding as described above, it is easy to realize a wall thickness that is thinner at the cap portion of the bottom than at the cylindrical portion. Thus, a dimension of the entire spindle motor in the axial direction can be reduced (to be lower profile). Alternatively, if the dimension of the entire spindle motor in the axial direction is restricted, a length of the radial bearing in the axial direction can be increased as much as possible so that rigidity against a load that causes inclination of the bearing can be enhanced.

[0019] Moreover, the assembling method of the present invention is used preferably for a bearing structure in which lubricating oil is kept between the opening end surface of the housing and the rotor hub so that a thrust fluid dynamic pressure bearing is formed. According to this structure, the thrust fluid dynamic pressure bearing can improve durability of the entire bearing.

[0020] Moreover, the assembling method of the present invention is used preferably for a bearing structure in which lubricating oil is kept between the opening end surface of the housing and the rotor hub as well as between the stopper member and the end surface of the sleeve so that thrust fluid dynamic pressure bearings are formed. This structure is a so-called double thrust structure, which can further improve durability of the entire bearing. In addition, it is necessary to secure high accuracy of the axial gap between the opening end surface of the housing and the rotor hub as well as between the stopper member and an end surface of the sleeve in this structure. The assembling method of the present invention enables to secure high accuracy even if the one body of housing of a cylindrical shape with one closed end is used.

[0021] Moreover, in the method of the present invention for assembling a bearing as described above, the step (b) preferably includes inserting the sleeve into the housing until the opening end surface of the housing abuts the rotor hub, and the step (d) preferably includes pulling one of the housing and the hub assembly from the other relatively in the axial direction by a predetermined distance, and the step (e) preferably includes placing a magnet outside the bottom of the housing so as to exert the force on the sleeve. This shows an example of means for exerting the force on the sleeve, in which an attraction force of a magnet is utilized for moving the sleeve toward the bottom of the housing.

[0022] Moreover, in the method of the present invention for assembling a bearing as described above, it is preferable that the sleeve be made of a ferromagnetic material or a material containing a ferromagnetic material, and that the step (e) include placing a magnet outside the bottom of the housing so as to exert the force on the sleeve. This shows an example of means for exerting the force on the sleeve, in which an attraction force of a magnet is utilized for moving the sleeve toward the bottom of the housing.

[0023] Moreover, in the method of the present invention for assembling a bearing as described above, the step (c) preferably includes applying an inertial force to the housing and the hub assembly as a lump so as to exert the force on the sleeve. An example of a method for applying an inertial force may include fixing the housing and the hub assembly as a lump to a rotating tool so that a centrifugal force due to the rotation is applied to them as an inertial force. By fixing them to the rotating tool with the housing toward the outside, the inertial force is applied to the sleeve in the direction toward the bottom of the housing. Thus, the sleeve can be moved toward the bottom of the housing.
Moreover, in the method of the present invention for assembling a bearing as described above, it is preferable that the step (b) include applying an adhesive to the outer surface of the sleeve or the inner surface of the housing before inserting the sleeve into the housing, and that the steps (c) and (d) be performed before the adhesive is cured, and that step (e) include curing the adhesive to fix the sleeve to the housing. According to this method, viscosity of the adhesive before curing can be utilized for performing registration of the sleeve with the housing effectively and precisely.

Moreover, it is preferable that the method of the present invention for assembling a bearing further includes the step, between the steps (d) and (e), of curing a part of the adhesive between the outer surface of the sleeve and the inner surface of the housing as temporary fixing. When a thermosetting adhesive is used for example, a part of an area to which the adhesive is applied is heated rapidly for curing and temporary fixing. Then, the entire assembly is put in a curing oven so that the entire adhesive is cured. In this way, the temporary fixing can prevent the relative position between the sleeve and the housing in the axial direction after the registration from shifting before the adhesive is cured.

Moreover, in the method of the present invention for assembling a bearing as described above, the step (b) preferably includes applying an adhesive that is cured in a short time for temporary fixing to a part and applying an adhesive that is cured in a long time to the other part of the outer surface of the sleeve or the inner surface of the housing. According to this method, the relative position between the sleeve and the housing in the axial direction after the registration is fixed temporarily by the adhesive for temporary fixing and then is fixed securely by the adhesive that is cured in a long time. Therefore, similarly to the effect described above, the relative position between the sleeve and the housing in the axial direction after the registration can be prevented from shifting before the adhesive (for production fixing) is cured.

Moreover, it is preferable that the method of the present invention for assembling a bearing preferably further include the step, after the step (e), of filling lubricating oil in a space including a radial gap formed between the sleeve and the shaft and an axial gap between the opening end surface of the housing and the rotor hub as well as between the stopper member and the end surface of the sleeve. Thus, it is possible to realize a bearing structure with high durability, in which a radial bearing and a thrust bearing are filled with lubricating oil.

**BRIEF DESCRIPTION OF THE DRAWINGS**

**FIG. 1** is a cross section showing a bearing structure of a spindle motor according to an example of the present invention.

**FIGS. 2(a) and 2(b)** show examples of a cross-sectional shape of a housing. In the example shown in **FIG. 2(a)**, a wall thickness of the cap portion 11a is substantially the same as a wall thickness of the cylindrical portion 11b (at the part close to the cap portion 11a except the upper part). In the example shown in **FIG. 2(b)**, on the contrary, a wall thickness of the cap portion 11a is smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b as shown in **FIG. 2(b)**. Thus, an axial direction of the entire spindle motor can be reduced to respond a request for a low profile. Alternatively, if the dimension of the entire spindle motor in the axial direction is restricted, a length of the radial bearing in the axial direction can be increased as much as possible so that rigidity against a load that causes inclination of the bearing can be enhanced. Note that a wall thickness of the upper portion of the cylindrical portion 11b increases gradually toward the upper end (opening end), and the reason of

**FIGS. 4(a) and 4(b)** show examples of a force that is exerted on the sleeve.

**FIG. 5** shows an example of a method for adjusting an axial gap.

**FIGS. 6(a) and 6(b)** show a preferred example in which the sleeve is fixed to the housing by adhesive.

**FIG. 7** shows another example in which the sleeve and the housing are fixed to each other by adhesive.

**FIG. 8** shows a conventional bearing structure of a spindle motor.

**DESCRIPTION OF THE PREFERRED EMBODIMENTS**

Hereinafter, examples of the present invention will be described with reference to the attached drawings. Note that when a position or a direction of each member is expressed by up, down, right and left in the following description, it merely means a position or a direction in a drawing and does not mean a position or a direction in a real apparatus.

**FIG. 1** is a cross section showing a bearing structure of a spindle motor according to an example of the present invention. This bearing structure includes a housing 11 of a cylindrical shape with one closed end, a sleeve 12 of a hollow cylindrical shape fixed to the inner surface of the housing 11, a shaft 13 that is inserted in the sleeve 12 in a rotatable manner, a rotor hub 14 having substantially a disk shape formed integrally with the shaft 13 and connected to the proximal end of the shaft 13 at the middle portion, and a stopper member 15 fixed to the distal end of the shaft 13 so as to be positioned at the bottom side of the housing 11.

The housing 11 has a cylindrical shape with one closed end (like a cup) and is made up of a cylindrical portion and a cap portion for closing one end of the cylindrical portion. The housing 11 can be formed by press molding of a sheet metal, for example. It is advantageous in cost and administration compared with the conventional housing made up of the cylindrical member and the cap member. In addition, it is not necessary to seam the cylindrical member with the cap member in the assembling process, and an inspection step for checking a sealed state of the sealed part is not necessary too, unlike the conventional structure.

**FIGS. 2(a) and 2(b)** show examples of a cross-sectional shape of a housing 11. In the example shown in **FIG. 2(a)**, a wall thickness of the cap portion 11a is substantially the same as a wall thickness of the cylindrical portion 11b (at the part close to the cap portion 11a except the upper part). In the example shown in **FIG. 2(b)**, on the contrary, a wall thickness of the cap portion 11a is smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b. When the housing 11 is formed by press molding, it is easy to make a wall thickness of the cap portion 11a smaller than a wall thickness of the cylindrical portion 11b.

Thus, an axial direction of the entire spindle motor can be reduced to respond a request for a low profile. Alternatively, if the dimension of the entire spindle motor in the axial direction is restricted, a length of the radial bearing in the axial direction can be increased as much as possible so that rigidity against a load that causes inclination of the bearing can be enhanced. Note that a wall thickness of the upper portion of the cylindrical portion 11b increases gradually toward the upper end (opening end), and the reason of

**FIGS. 6(a) and 6(b)** show a preferred example in which the sleeve is fixed to the housing by adhesive.
it is to constitute a capillary seal portion for preventing lubricating oil from leaking as described later.

[0040] The sleeve 12 is preferably a porous sintered body made of metal powder or metal oxide powder, which is molded and sintered, and then impregnated with lubricating oil. In particular, it is preferable that the sleeve 12 is made of a ferromagnetic material or a material containing a ferromagnetic material in order that the sleeve 12 is forced to move by a magnet in an assembling process that will be described later. The sleeve 12 is fixed to the inner surface of the housing 11 by means of adhesive or the like. On this occasion, precise registration between the housing 11 and the sleeve 12 in the axial direction is necessary.

[0041] The shaft 13 is formed integrally with the rotor hub 14 having substantially a disk shape and extends from the middle portion of the rotor hub 14 perpendicularly. Therefore, it is possible to improve accuracy of perpendicularity and the like of the shaft 13 with respect to the rotor hub 14. In addition, the entire spindle motor can be adapted to be small and compact. It is also advantageous in cost and administration compared with the structure made up of separated bodies of the shaft and the rotor hub. In addition, it is not necessary to connect them in the assembling process so that the number of man-hour can be reduced.

[0042] The rotor hub 14 includes a disk portion 14a of a disk-like shape extending in the radial direction from the proximal end (upper end) of the shaft 13, a cylindrical wall portion 14b extending in the axial direction from the rim portion of the disk portion 14a coaxially with the shaft 13 and a flange portion 14c extending in a step shape outward in the radial direction further from the cylindrical wall portion 14b. This spindle motor is used for a hard disk driving device, so a recording medium (hard disk) to be driven to rotate is put on and fixed to the upper surface of the rotor hub 14 (the upper surface of the disk portion 14a and the flange portion 14c). In addition, a rotor magnet 16 of a ring shape is fixed to the outer surface of the cylindrical wall portion 14b and the lower surface of the flange portion 14c by means of adhesive or the like. A stator armature 17 is arranged so as to face the rotor magnet 16 with a predetermined gap in the radial direction.

[0043] The stopper member 15 includes a shank portion 15a that is inserted in and fixed to the distal end (lower end) of the shaft 13 and a flange portion 15b of a disk-like shape extending in the radial direction from the proximal end of the shank portion 15a, which are formed integrally. The distal end of the shaft 13 is provided with an internal thread while the shank portion 15a of the stopper member 15 is provided with an external thread, which are engaged with each other so that the stopper member 15 is fixed to the distal end of the shaft 13. Alternatively, it is possible to use means of adhesive or the like for fixing them to each other.

[0044] The stopper member 15 has a function of preventing the shaft 13 and the rotor hub 14 from being off (detached) upward from the sleeve 12 and the housing 11 by abutting the lower end surface of the sleeve 12 at the upper surface of the flange portion 15b. The shaft 13 and the rotor hub 14 are integrated to be one component, and the disk portion 14a of the rotor hub 14 covers the upper opening of the housing 11. In addition, the cap portion 11a and the cylindrical portion 11b of the housing 11 are integrated to be one component. Therefore, assembling order of the housing 11, the sleeve 12, the shaft 13 (the rotor hub 14) and the stopper member 15 has a restriction, and it is necessary to devise a method of assembling them as being described later in detail.

[0045] A radial gap is formed between the sleeve 12 and the shaft 13 of the bearing structure. In addition, an axial gap is formed between the opening end surface of the cylindrical portion 11b of the housing 11 and the lower surface of the disk portion 14a of the rotor hub 14. Furthermore, another axial gap is formed between the upper surface of the flange portion 15b of the stopper member 15 and the end surface of the sleeve 12 as well as between the lower surface of the flange portion 15b and the upper surface of the cap portion 11a of the housing 11. A space including these gaps is filled with lubricating oil (fluid).

[0046] Therefore, the lubricating oil filled mainly inside the housing 11 migrates from the opening end surface of the cylindrical portion 11b to the outside of the housing 11, and a surface of the lubricating oil is positioned in the gap between the outer surface of the cylindrical portion 11b and the inner surface of the cylindrical wall portion 14b of the rotor hub 14. As understood from FIG. 1 and FIGS. 2(a) and 2(b), the housing 11 is formed so that a wall thickness of the cylindrical portion 11b increases gradually toward the upper end (opening end) at the upper portion. Therefore, the gap between the outer surface of the cylindrical portion 11b and the inner surface of the cylindrical wall portion 14b of the rotor hub 14 increases gradually from the upper end toward the lower end. Thus, a capillary seal portion is formed for preventing leakage of the lubricating oil. In other words, leakage of the lubricating oil from the gap between the outer surface of the cylindrical portion 11b and the inner surface of the cylindrical wall portion 14b of the rotor hub 14 to the outside (downward) can be prevented by surface tension of the lubricating oil and atmospheric pressure.

[0047] The outer surface of the shaft 13 or the inner surface of the sleeve 12 is provided with grooves for gathering the lubricating oil arranged in the rotation direction (herringbone grooves). More specifically, a plurality of grooves having a doglegged shape is formed sequentially in the circumferential direction. When the shaft 13 rotates, the lubricating oil is led into both ends of the doglegged groove and gathered to middle portion (inflection point) of the doglegged groove so that a pressure of the lubricating oil (a dynamic pressure) is generated at this point. Thus, a fluid dynamic pressure bearing is realized, in which the shaft 13 is retained by the sleeve 12 via the lubricating oil so that the shaft 13 can rotate at high speed. Two of such radial fluid dynamic pressure bearings 19 are disposed at two positions separated in the axial direction.

[0048] In addition, a first thrust fluid dynamic pressure bearing 20 that has a function similar to that of the radial fluid dynamic pressure bearing 19 is formed between the opening end surface of the cylindrical portion 11b of the housing 11 and the lower surface of the disk portion 14a of the rotor hub 14. Grooves that are formed on the opening end surface of the cylindrical portion 11b of the housing 11 or on the lower surface of the disk portion 14a of the rotor hub 14 may be the herringbone grooves like the radial fluid dynamic pressure bearing 19 or a helical groove. The helical groove has a function of gathering the lubricating oil inward in the radial direction against a centrifugal force that is exerted on
the lubricating oil when the rotor hub 14 rotates. A second thrust fluid dynamic pressure bearing 21 that has a structure and a function similar to those of the first thrust fluid dynamic pressure bearing 20 is formed between the upper surface of the flange portion 15b of the stopper member 15 and an end surface of the sleeve 12.

[0049] Note that there are various forms and combinations of structures concerning these fluid dynamic pressure bearings 19, 20 and 21. There is a case where only the radial fluid dynamic pressure bearing 19 is provided. In another case, the radial fluid dynamic pressure bearing 19 plus one of the thrust fluid dynamic pressure bearings 20 and 21 are provided. In addition, there is another case in which each of the upper and the lower sides of the stopper member 15 is provided with the thrust fluid dynamic pressure bearing. The present invention can be applied to any of these various forms of the fluid dynamic pressure bearings.

[0050] Next, a method for assembling the above-mentioned bearing structure will be described. First, an outline of the assembling method will be described with reference to FIG. 3. FIG. 3 shows assembling steps sequentially of the bearing structure according to an example of the present invention. Note that FIG. 3 shows the components of the bearing structure upside down with respect to FIG. 1, for matching with the real assembling works.

[0051] In the first step (a), the shaft 13 integrated with the rotor hub 14 is inserted in the sleeve 12, and the stopper member 15 is fixed to the distal end of the shaft 13 to be a hub assembly 23. In the actual work, the sleeve 12 is engaged with the shaft 13 of the rotor hub 14 that is placed so that the distal end of the shaft 13 faces upward, and then the stopper member 15 is fixed to the distal end of the shaft 13 by means of thread engagement, adhesive or the like. Note that lipophobic liquid is applied to a predetermined portion of the rotor hub 14 in advance.

[0052] In the next step (b), the sleeve 12 of the hub assembly 23 is inserted in the housing 11. In the actual work, the housing 11 is engaged with the sleeve 12 of the hub assembly 23 that is placed so that the stopper member 15 faces upward. Note that the housing 11 and the sleeve 12 are formed with accuracy in dimensions so that the inner surface of the housing 11 (the cylindrical portion 11b) can make substantially an intimate contact with the outer surface of the sleeve 12. In order to fix them to each other with adhesive, the sleeve 12 is inserted into the housing 11 after adhesive is applied to the inner surface of the housing 11 or the outer surface of the sleeve 12.

[0053] In the next step (c), the sleeve 12 is moved toward the bottom of the housing 11 (upward in FIG. 3) by exerting a force on the sleeve 12 utilizing a magnetic force or an inertial force that will be described later. This movement is stopped when an end surface of the sleeve 12 (the upper end surface in FIG. 3) abuts the stopper member 15 (the flange portion 15b). If adhesive exists between the inner surface of the housing 11 and the outer surface of the sleeve 12, this step has to be done before the adhesive is cured.

[0054] In the next step (d), the housing 11 is pulled relatively from the hub assembly 23 in the axial direction by a predetermined distance. In the example shown in FIG. 3, the housing 11 is held by a tool and pulled upward by a predetermined distance from the hub assembly 23 that is fixed to the lower side. This step also has to be done before adhesive is cured if it exists between the inner surface of the housing 11 and the outer surface of the sleeve 12. This step enables precise adjustment of the axial gap between the rotor (the rotor hub 14 and the stopper member 15) and the stator (the sleeve 12).

[0055] After that, the sleeve 12 is fixed to the housing 11 in the step (e). If adhesive exists between them, they are fixed to each other by curing the adhesive. For example, if thermosetting adhesive is used, the entire assembly is put in a curing oven and is baked at a predetermined temperature. Instead of the fixing method using adhesive, a laser welding method can be used for fixing the sleeve 12 to the housing 11. In this case, for example, plural small through holes for passing a laser beam are formed in the disk portion 14a of the rotor hub 14, and the laser beam passing through the holes can irradiate a scanning portion of the sleeve 12 with the housing 11. Finally, lubricating oil is filled in a space including the radial gap between the sleeve 12 and the shaft 13, the axial gap between the opening end surface of the housing 11 and the rotor hub 14, and the axial gap between the stopper member 15 and the end surface of the sleeve 12 (mainly inside the housing 11).

[0056] FIGS. 4(a) and 4(b) show examples of a force that is exerted on the sleeve 12 in the step (c). In the example shown in FIG. 4(a), a magnetic force is used for exerting on the sleeve 12. In order to use this method, the sleeve 12 must be made of a ferromagnetic material or a material containing a ferromagnetic material. Then, on magnet MG is placed outside the bottom of the housing 11, so that the sleeve 12 is attracted to move toward the bottom of the housing. The state before the magnet MG is placed where the lower end surface of the sleeve 12 abuts the rotor hub 14 becomes the state after the magnet MG is placed where the upper end surface of the sleeve 12 abuts the stopper member 15 as shown in FIG. 4(a).

[0057] In the example shown in FIG. 4(b), a centrifugal force (inertial force) is utilized for exerting on the sleeve 12. More specifically, the entire assembly of the housing 11 and the hub assembly 23 is fixed to the rotating tool RT, which is rotated at a predetermined angular velocity \( \omega \). In this case, the entire assembly is fixed so that the housing 11 faces outside of the rotation. A centrifugal force that is proportional to a mass and a radius of rotation and a square of the angular velocity \( \omega \) is exerted on each member, but the housing 11 and the hub assembly 23 are fixed to the rotating tool RT. Therefore, only the sleeve 12 is forced to move toward the bottom of the housing. As a result, the state where the upper end surface of the sleeve 12 abuts the stopper member 15 is obtained as shown in FIG. 4(b). Note that after the rotating tool RT stops the above-mentioned state of the relative position is maintained by a frictional force between the inner surface of the housing 11 and the outer surface of the sleeve 12 or by viscosity of the adhesive that exists between them.

[0058] FIG. 5 shows an example of a method for adjusting an axial gap in the step (d). In this example, the hub assembly 23 is placed on a table and fixed to the same so that the housing 11 faces upward, and the bottom of the housing 11 (the cap portion 11a) and the outer surface of the cylindrical portion 11b are held by a vacuum chuck VC. In the example shown in FIG. 5, the magnet MG placed on the
outside of the bottom surface of the housing 11 is held together. Then, the housing 11 held by the vacuum chuck VC is pulled up by a predetermined distance corresponding to a desired axial gap AG so that the housing 11 is away from the hub assembly 23.

[0059] In a preferred embodiment of the adjusting method, the sleeve 12 is inserted into the housing 11 until the opening end surface of the housing 12 abuts the disk portion 14c of the rotor hub 14 in the step (b). This state is a reference position (start position), and from this reference position the housing 12 is pulled away from the hub assembly 23 in the axial direction in the step (d) by a distance corresponding to the axial gap between the opening end surface of the housing 11 and the rotor hub 14 plus the axial gap between the stopper member 15 and the end surface of the sleeve 12 after assembling. Thus, the sum of these two axial gaps is adjusted precisely as the axial gap AG that is a predetermined distance mentioned above.

[0060] FIGS. 6(a) and 6(b) show a preferred example in which the sleeve 12 is fixed to the housing 11 by adhesive. FIG. 6(b) is an enlarged view of FIG. 6(a). In this example, when adhesive is applied to the inner surface of the housing 11 or the outer surface of the sleeve 12 in the step (b) mentioned above, adhesive that is cured in a short time for temporary fixing is applied to a part of the applied area while adhesive that is cured in a long time is applied to the other part of the area. More specifically, anaerobic adhesive (e.g., an acrylic adhesive) that is cured in a short time (approximately 2-3 minutes) is applied to a minor part area AR1 that is closer to the bottom of the housing 11 within the adhesive-applied area AR between the sleeve 12 and the housing 11, while thermosetting adhesive (e.g., an epoxy adhesive) is applied to the other major part area AR2.

[0061] In step (d), the state where the axial gap is adjusted is maintained 1-3 minutes, so that the adhesive for temporary fixing applied to a part area AR1 is cured. After that, the vacuum chuck VC can be removed from the housing 11 while the relative position between the sleeve 12 and the housing 11 is maintained by the temporary fixing. Then, the entire assembly is put in the curing oven and baked. Thus, the thermosetting adhesive applied to the major part area AR2 is cured so that the sleeve 12 and the housing 11 are fixed to each other.

[0062] FIG. 7 shows another example in which the sleeve 12 and the housing 11 are fixed to each other by adhesive. The FIG. 7 corresponds to the enlarged view of shown in FIG. 6(b). In this example, when adhesive is applied to the inner surface of the housing 11 or the outer surface of the sleeve 12 in the above-mentioned step (b), thermosetting adhesive (e.g., an epoxy adhesive) is applied to the entire adhesive-applied area AR. Then, a heater HT is disposed at the inner surface of vacuum chuck VC at the distal end portion that contacts the outer surface of the cylindrical portion 11b of the housing 11.

[0063] In the step (d), electric power is supplied to the heater HT of the vacuum chuck VC at the distal end portion in the state where the axial gap is adjusted. Then, the cylindrical portion 11b of the housing 11 is heated by the heater HT, and the heat conducts to the thermosetting adhesive. As a result, a part of the thermosetting adhesive is rapidly heated and cured as to work for temporary fixing. After that, the vacuum chuck VC can be removed from the housing 11 while the relative position between the sleeve 12 and the housing 11 is maintained by the temporary fixing. Then, the entire assembly is put in the curing oven and baked. Thus, the thermosetting adhesive is completely cured so that the sleeve 12 and the housing 11 are fixed to each other.

[0064] Although examples of the present invention are described together with some variations above, the present invention can be embodied variously without being limited to the above-described examples and variation. In addition, materials and shapes of each member that are shown in the above description of examples are merely examples, and it should not be interpreted that a structure of the present invention is limited to those materials and shapes.

What is claimed is:
1. A method for assembling a bearing of a spindle motor, the bearing comprising:
   a housing of a cylindrical shape with one closed end, made up of a cylindrical portion and a cap portion for closing one end of the cylindrical portion;
   a sleeve of a hollow cylindrical shape fixed to the inner surface of the housing;
   a shaft inserted in the sleeve in a rotatable manner;
   a rotor hub having substantially a disk shape formed integrally with the shaft and connected to the proximal end of the shaft at the middle portion; and
   a stopper member fixed to the distal end of the shaft so as to be positioned at the bottom side of the housing, wherein
   a radial gap is formed between the sleeve and the shaft, and an axial gap is formed between the opening end surface of the housing and the rotor hub as well as between the stopper member and an end surface of the sleeve, the method comprising the steps of:
   (a) inserting the shaft integrated with the rotor hub into the sleeve and fixing the stopper member to the distal end of the shaft so as to make a hub assembly;
   (b) inserting the sleeve into the housing;
   (c) exerting a force on the sleeve to move toward the bottom of the housing until an end surface of the sleeve abuts the stopper member;
   (d) pulling one of the housing and the hub assembly from the other relatively in the axial direction by a predetermined distance; and
   (e) fixing the sleeve to the housing.
2. The method according to claim 1, wherein the housing is formed to have a wall thickness that is thinner at the cap portion than at the cylindrical portion.
3. The method according to claim 1, wherein lubricating oil is kept between the opening end surface of the housing and the rotor hub so that a thrust fluid dynamic pressure bearing is formed.
4. The method according to claim 1, wherein lubricating oil is kept between the opening end surface of the housing and the rotor hub as well as between the stopper member and the end surface of the sleeve so that thrust fluid dynamic pressure bearings are formed.
5. The method according to claim 1, wherein the step (b) includes inserting the sleeve into the housing until the opening end surface of the housing abuts the rotor hub, and the step (d) includes pulling one of the housing and the hub assembly from the other relatively in the axial direction by a distance that is equal to an axial gap between the opening end surface of the housing and the rotor hub plus an axial gap between the stopper member and an end surface of the sleeve after assembling.

6. The method according to claim 1, wherein the sleeve is made of a ferromagnetic material or a material containing a ferromagnetic material, and the step (c) includes placing a magnet outside the bottom of the housing so as to exert the force on the sleeve.

7. The method according to claim 1, wherein the step (c) includes applying an inertial force to the housing and the hub assembly as a lump so as to exert the force on the sleeve.

8. The method according to claim 1, wherein the step (b) includes applying an adhesive to the outer surface of the sleeve or the inner surface of the housing before inserting the sleeve into the housing, and the steps (c) and (d) are performed before the adhesive is cured, and the step (e) includes curing the adhesive to fix the sleeve to the housing.

9. The method according to claim 8, further comprising the step, between the steps (d) and (e), of curing a part of the adhesive between the outer surface of the sleeve and the inner surface of the housing as temporary fixing.

10. The method according to claim 8, wherein the step (b) includes applying an adhesive that is cured in a short time for temporary fixing to a part and applying an adhesive that is cured in a long time to the other part of the outer surface of the sleeve or the inner surface of the housing.

11. The method according to claim 1, further comprising the step, after the step (c), of filling lubricating oil in a space including a radial gap formed between the sleeve and the shaft and an axial gap between the opening end surface of the housing and the rotor hub as well as between the stopper member and an end surface of the sleeve.

12. The method according to claim 9, further comprising the step, after the step (c), of filling lubricating oil in a space including a radial gap formed between the sleeve and the shaft and an axial gap between the opening end surface of the housing and the rotor hub as well as between the stopper member and an end surface of the sleeve.