

SINTERED BEARING AND METHOD OF PRODUCING THE SAME

BACKGROUND OF THE INVENTION

The present invention relates to a sintered bearing having steel balls or ceramic balls on an end face thereof, and also relates to a method of producing such a sintered bearing. More particularly, the present invention relates to a sintered bearing, e.g. an oilless bearing, having steel balls or ceramic balls on an end face thereof which has been subjected to density correction and grinding, and also relates to a method of producing such a sintered bearing.

Generally, when powder placed in a die is compressed, it is necessary to increase the compressive force in order to increase the density of the resulting green compact. However, it is difficult to increase the density to a level higher than a certain limit because of the press capacity and the die strength. Accordingly, the conventional practice is to subject a sintered body to coining and sizing, and when it is desired to grind an end face of the sintered body, the common practice is to perform grinding using a lathe as a secondary operation. However, such a conventional practice is extremely troublesome, and is unsuitable for the mass production of bearings such as oilless bearings.

Under these circumstances, there has heretofore been proposed a technique whereby a sintered body is placed in a die and subjected to density correction and grinding for an end face by using a punch for pressing the sintered body and

a rotatable punch which is provided in the center of the pressing punch (see Japanese Utility Model Application Post-Examination Publication No. 55-40173).

The above-described conventional technique enables the density correction of a sintered body and grinding of an end face of the sintered body, and thus makes it possible to improve the operating efficiency. However, the conventional technique has the problem on such a sintered bearing that the bearing cannot satisfactorily support the action load imposed on the end face of the bearing, i.e. the bearing cannot be adopted for a rotating shaft on which a load is applied in the axial direction, in the case of one produced by just grinding an end face thereof and impregnating it with oil. For example, when a journal which is subjected to an axial load rotates at high speed, or when the axial load is heavy, the journal cannot smoothly rotate, causing generation of heat.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide a sintered bearing having steel balls or ceramic balls on an end face thereof so that the sintered bearing can cope with a load acting on the end face thereof, and also provides a method which enables such a sintered bearing to be mass-produced with high accuracy and at high efficiency.

To solve the above-described problems, the present invention provides a sintered bearing including a sintered

cylindrical body which has been subjected to sintering, correcting, and oil impregnation. The sintered cylindrical body has a groove on an end face thereof. A plurality of steel balls or ceramic balls are rotatably mounted in the groove. The inner peripheral surface of the sintered cylindrical body supports a peripheral journal of a rotating shaft, and the steel or ceramic balls on the end face of the sintered cylindrical body support a journal which is subjected to a load in the direction of the axis of rotation.

In addition, the present invention provides a method of producing a sintered bearing having steel balls or ceramic balls on an end face thereof. The method includes the steps of: forming a cylindrical green compact having an annular groove on an end face thereof, and sintering the green compact by heating to form a sintered cylindrical body; placing the sintered cylindrical body in a die and grinding the sintered cylindrical body while pressing it from both the upper and lower sides thereof by applying, to the end face of the sintered cylindrical body which has the groove, a cylindrical punch for pressing the outer surface of the groove, and a punch which is vertically movable and rotatable in a hollow portion of the cylindrical punch and provided at an end thereof with an annular projection-shaped cutter corresponding to the groove, and further inserting a core rod into the inner peripheral surface of the sintered cylindrical body, thereby correcting the sintered cylindrical body; and subjecting the sintered cylindrical

body to oil impregnation, and thereafter, inserting steel balls or ceramic balls into the groove on the end face of the sintered cylindrical body, and carrying out working to prevent the steel or ceramic balls from coming out of the groove.

In the above-described method, the core rod inserted into the inner peripheral surface of the sintered cylindrical body is preferably rotated.

In the present invention, the annular groove which is provided on the end face of the sintered cylindrical body to accommodate the steel or ceramic balls may have any cross-sectional configuration, provided that the steel or ceramic balls can operate as a roller bearing in the groove. For example, the groove may be a U-groove, a V-groove, or a groove with a bottom surface having a pentagonal cross-sectional configuration.

In the present invention, steel balls or ceramic balls are provided on an end face of a sintered bearing to cope with a load acting on the end face. Thus, the steel or ceramic balls on the end face of the sintered bearing contact a journal of a rotating part and enable the rotating part to rotate smoothly with a compact and thin sintered bearing even when the axial load is heavy.

Further, sizing, coining and repressing for improving the physical properties, for example, increasing the density, are simultaneously effected by grinding the sintered cylindrical body while pressing it from both the upper and lower sides thereof, thereby enabling the sintered

bearing to be mass-produced with high accuracy and at high efficiency.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view showing one embodiment of the sintered bearing according to the present invention.

Fig. 2 illustrates the process for forming a green compact in one embodiment of the sintered bearing producing method according to the present invention.

Fig. 3 illustrates the correcting process for the sintered body in the embodiment of the present invention.

Fig. 4 shows an enlarged plan view of a cutter used in the correcting process in the embodiment of the present invention and a sectional view of a sintered cylindrical body.

Fig. 5 illustrates the removal of the sintered cylindrical body after the correcting process in the embodiment of the present invention.

Fig. 6 illustrates the process for rotatably mounting steel balls in the groove so as to prevent them from coming

out of the groove in the embodiment of the present invention.

Fig. 7 shows sketches of the sintered bearing according to the embodiment of the present invention.

Fig. 8 shows an enlarged plan view of a cutter used in the correcting process in another embodiment of the present invention and a sectional view of a sintered cylindrical body in this embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiments of the present invention will be described below with reference to the accompanying drawings.

A first embodiment of the present invention is shown in Fig. 1.

Part (a) of Fig. 1 is a sectional view of a sintered bearing according to the present invention. A sintered cylindrical body 8, which has been subjected to sintering, correcting, and oil impregnation, has steel balls (or ceramic balls) 19 provided in a groove 17 formed in an end face 21 of the sintered cylindrical body 8. The steel balls 19 function as rollers in the groove 17. The sintered cylindrical body 8 has an inner peripheral surface 22 smoothed by the correcting process for the sintered cylindrical body 8.

Part (b) of Fig. 1 shows the sintered bearing according to the present invention and journals of a rotating part.

The steel balls 19 on the sintered bearing end face 21 are contacted by a journal 25 of a rotating part 23. A

plurality of steel balls 19 on the end face 21 function as a bearing for supporting a load acting on the journal 25 in the direction of the axis of rotation, i.e. in the vertical direction as viewed in the figure. The inner peripheral surface 22 is contacted by a journal 24 of the rotating part 23 and thus functions as a bearing. The sintered bearing, which has a plurality of steel balls in the end face groove, enables the journals 24 and 25 of the rotating part 23 to rotate smoothly even when they rotate at high speed, or the axial load is heavy.

It has heretofore been necessary in order to enable the rotating part 23 to rotate smoothly to increase the height of the sintered cylindrical body 8 (i.e. to lengthen the inner peripheral surface 22) and to use a long journal 24 which is rotatably supported by the sintered cylindrical body 8. In the sintered bearing according to the present invention, however, steel balls on the sintered bearing end face contact the journal of the rotating part, thereby enabling the rotating part to rotate smoothly at high speed even where an axial load is being applied with a compact and thin sintered bearing.

A second embodiment of the present invention will be described below with reference to Figs. 2 to 7.

Fig. 2 illustrates in parts (a) to (c) the compacting process for forming a green compact, and Fig. 3 illustrates the process of pressing and grinding a sintered cylindrical body. Part (a) of Fig. 4 is an enlarged plan view of an annular projection-shaped cutter used in the press-grinding

process. Part (b) of Fig. 4 is a sectional view of a sintered cylindrical body. Fig. 5 illustrates the removal of the sintered cylindrical body after the press-grinding process. Fig. 6 illustrates in parts (a) to (c) the process of inserting steel balls into an end face groove and carrying out working to prevent the steel balls from coming out of the groove, and Fig. 7 shows in parts (a) and (b) a sintered bearing having steel balls on an end face thereof.

In the compacting process for forming a cylindrical green compact having an annular groove on an end face thereof, as shown in part (a) of Fig. 2, first, powder is charged into a cavity defined in a die 2 with a core rod 7 projecting into the center of the die 2 from below it, and the powder is compressed. Compression of the powder from the upper side is effected by a combination of a first upper punch 3 which is cylindrical and has a die 5, and a cylindrical second upper punch 4 which is slidable on the cylindrical inner surface of the first upper punch 3 and which enables the lower core rod 7 to be inserted into the center thereof. Compression of the powder from the lower side is effected by a cylindrical lower punch 6 having the core rod 7 inserted in the center thereof.

In the compacting process for forming a cylindrical green compact, the die 5 of the first upper punch 3 is a die which is provided with an annular projection 51, as shown in part (b) of Fig. 2, to form an annular groove in an end face of a cylindrical green compact 1, as shown in part (c) of Fig. 2.

It should be noted that a die used to form an annular groove in the end face of the cylindrical green compact 1 is not necessarily limited to the above-described die 5, and that it is also possible to use a combination of a plurality of cylindrical punches which are slidably provided so as to define a shape corresponding to an annular groove to be formed in the end face of the cylindrical green compact 1.

After the completion of the compacting process for forming a cylindrical green compact, the first upper punch 3 and the second upper punch 4 are withdrawn, and the lower punch 6 is raised upwardly to push up the green compact, thereby removing it as a formed piece 1.

Next, the cylindrical green compact, formed by the above-described compacting process, is sintered at an appropriate temperature and in an appropriate atmosphere. Examples of usable materials are Cu-Sn, Fe-Cu, Fe and stainless steel powders. The sintering process is carried out, for example, as follows: In the case of Cu-Sn powder, the temperature is in the range of from 700 to 900°C; in the case of Fe-Cu powder, the temperature is in the range of from 900 to 1,100°C; in the case of Fe powder, the temperature is in the range of from 1,000 to 1,200°C; and in the case of stainless steel powder, the temperature is in the range of from 1,000 to 1,200°C. The sintering process is carried out in a non-oxidizing atmosphere, e.g. in a hydrogen atmosphere.

Next, the correcting process in which the sintered cylindrical body is simultaneously pressed and ground is

shown in Figs. 3, 4 (parts (a) and (b)) and 5.

As shown in Fig. 3, the sintered cylindrical body 8 is set between a correcting die 9 and a correcting core rod 14 placed in the center of the die 9. The end face of the sintered cylindrical body 8, which has the annular groove, is provided thereon with a correcting first upper punch 10 which is a cylindrical punch for pressing the outer surface of the groove, and a correcting second upper punch 11 which is vertically movable and rotatable in the cylindrical hollow portion of the first upper punch 10.

The correcting second upper punch 11 is provided with an annular projection-shaped cutter corresponding to the groove of the sintered cylindrical body 8.

The correcting core rod 14, which constitutes a core, is inserted into the inner peripheral surface of the sintered cylindrical body 8. The correcting core rod 14 is vertically movable in the center of a correcting lower punch 13.

The upper end face of the sintered cylindrical body 8, which has the groove, is pressed by the first upper punch 10 and the rotatable second upper punch 11, and the lower end face of the sintered cylindrical body 8 is pressed by the lower punch 13.

Part (a) of Fig. 4 shows the annular projection-shaped cutter 12, which is provided at the end of the correcting second upper punch 11. The cutter 12 is provided with an annular projection 15 having a shape corresponding to the groove on the end face of the sintered cylindrical body.

The annular projection 15 is provided with a plurality of grooves 16.

In the correcting process for the sintered cylindrical body, the sintered body 8 is placed in the die 9, and pressure is applied to the sintered body 8 to effect sizing for obtaining the desired dimensions, coining for defining the surface configuration, and repressing for improving the physical properties, e.g. increasing the density. In regard to the oil-impregnated bearing according to the present invention in particular, the correcting process is carried out to mainly effect sizing while also effecting coining and repressing.

That is, as shown in part (a) of Fig. 4, the annular projection 15 of the correcting cutter 12 is provided with grooves 16 which function as cutting edges. By rotating the correcting cutter 12, the annular groove 17 on the upper surface of the sintered body 8, shown in part (b) of Fig. 4, is mirror-finished.

The center hole of the sintered body 8, shown in part (b) of Fig. 4, is subjected to sizing by the correcting core rod 14, shown in Fig. 3. It is desirable to rotate the correcting core rod 14 in order to effect the sizing even more efficiently and to attain a high dimensional accuracy.

Part (a) of Fig. 8 shows another example of the correcting cutter 12 and annular groove 17. The annular projection 15 is angular, and the annular groove 17 also has an angular cross-sectional configuration. In this case, during the compacting process for forming the cylindrical

green compact, the annular groove is formed so as to have an angular cross-sectional configuration.

After the completion of the correcting process, as shown in Fig. 5, the correcting first upper punch 10 and the correcting second upper punch 11 are withdrawn upwardly, and the lower punch 13 is pushed up to remove the corrected sintered body 8 from the die 9.

Next, the sintered body is subjected to oil impregnation.

To impregnate the sintered body with an oil, for example, the sintered body is placed in a container, and the pressure in the container is reduced. Then, a lubricating oil is injected into the container, and the sintered body is allowed to stand in the container under a reduced pressure. Consequently, the oil enters the pores of the sintered body in place of air. Alternatively, the sintered body may be dipped in the oil without reducing pressure.

Next, as shown in part (a) Fig. 6, a desired number of steel balls 19 are inserted into the annular groove 17 on the upper surface of the sintered body 8.

Next, as shown in part (b) of Fig. 6, caulking is carried out by using a pressing tool 20. Although only the cross-section thereof is shown in the figure, the pressing tool 20 is a cylindrical tool which effects caulking by its pressing surface for the steel balls 19 inserted into the annular groove 17.

As shown in part (c) of Fig. 6, the groove 17 of the sintered body 8 is deformed by caulking with the pressing

tool 20, thereby preventing the steel balls 19 from coming out of the groove 17.

As shown in parts (a) and (b) of Fig. 7, the sintered bearing produced by the process according to the present invention has steel balls 19 inserted in the upper surface of the sintered body 8.

As has been described above, the present invention provides an advantageous effect that the sintered bearing according to the present invention can cope with a load acting on an end face thereof by having steel or ceramic balls on the end face. In the production method, at the correcting step in particular, the sintered cylindrical body is ground while being pressed from both the upper and lower sides thereof, thereby simultaneously effecting sizing for obtaining the desired dimensions, coining for defining the surface configuration, and repressing for improving the physical properties, e.g. increasing the density. Thus, the sintered bearing can be mass-produced with high accuracy and at high efficiency.



WHAT WE CLAIM IS:

1. A sintered bearing comprising:

a sintered cylindrical body which has been subjected to sintering, correcting, and oil impregnation, said sintered cylindrical body having a groove on an end face thereof; and

a plurality of steel balls or ceramic balls which are provided in said groove;

wherein an inner peripheral surface of said sintered cylindrical body supports a peripheral journal of a rotating shaft, and said steel or ceramic balls on the end face of said sintered cylindrical body support a journal which is subjected to a load in a direction of an axis of rotation.

2. A method of producing the sintered bearing of claim 1, said method comprising the steps of:

forming a cylindrical green compact having an annular groove on an end face thereof, and sintering said green compact to form a sintered cylindrical body;

placing said sintered cylindrical body in a die and grinding said sintered cylindrical body while pressing it from both upper and lower sides thereof by applying, to the end face of said sintered cylindrical body which has said groove, a cylindrical punch for pressing an outer surface of said groove, and a punch which is vertically movable and rotatable in a hollow portion of said cylindrical punch and provided at an end thereof with an annular projection-shaped cutter corresponding to said groove, and further inserting a core rod into an inner peripheral surface of said sintered cylindrical body, thereby correcting said sintered



cylindrical body; and

subjecting said sintered cylindrical body to oil impregnation, and thereafter, inserting steel balls or ceramic balls into said groove on the end face of said sintered cylindrical body, and carrying out working to prevent said steel or ceramic balls from coming out of said groove.

3. A sintered bearing producing method according to claim 2, wherein said core rod inserted into the inner peripheral surface of said sintered cylindrical body is rotated.