ROLLER CONE BIT BEARING, AND BEARING MATERIALS

RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of co-pending U.S. Provisional Application Ser. No. 60/949,756, filed July 13, 2007, the full disclosure of which is hereby incorporated by reference herein.

BACKGROUND

1. Field of Invention

[0002] This disclosure relates to a journal bearing for a roller cone bit. Specifically, it concerns a set of bearing element materials, a method of manufacturing the bearing elements, and a manner of securing these bearing elements to a roller cone bit.

2. Description of Prior Art

[0003] Drill bits used in drilling of subterranean well bores typically comprise drag bits and roller cone bits. Roller cone bits typically comprise a body having legs extending downward and a head bearing extending from the leg towards the axis of the bit body. Frusto-conically shaped roller cones are rotatably mounted on each of these journals and are included with cutting teeth on the outer surface of these cones. Because of the high stresses incurred during drilling operations, the bearing mating surfaces within the bit require a bearing material or a surface treatment to sustain the loads and extend the bit life.

[00˘4 Figure 1 provides in a side cross-sectional view an example of a portion of a roller con e d rill bit 10. In this embodiment, the roller cone 12 mates with the head portion 14. A set of balls 16 is provided in an annular opening formed between the cone 12 and the head 14 and serves as a cone-retention system. A secondary purpose of the balls 16 is to provide a rolling

surface for facilitating rotation of the cone 12. Cone bearing surface 13 mates against and rotatably slides about head bearing surface 15. The respective surfaces (13, 15) must accommodate the high stress during the respective loading and rotation of these elements.

[0005] Traditionally, a journal bearing element 18 is disposed in a recess 19 circumferentially formed within the head section 14. The journal bearing element 18 accommodates the cone 12 rotation and the forces that the cone 12 may exert on the head section 14. The material used in forming the journal bearing element 18 varies; some are hard substances while others are soft, such as bronze and beryllium copper. In Figure 2, an example of a journal bearing element 18 is illustrated in a perspective view. The journal bearing element 18 is not a continuous ring but includes a separation 20 along the circumference of the journal bearing element 18. The separation 20 allows the journal bearing element 18 to be temporarily deformed during installation so it can be placed in the recess 19. Thus, should the journal bearing element 18 become galled and adhere to either one of the cone bearing surface 13 or the head bearing surface in the recess 19; the cone 12 can still rotate relative to the head 14 because one of the two bearing surfaces (13,19) is still rotatable. While the embodiment of Figure 1 does provide some redundancy in situations where seizing may occur between the journal bearing element 18 and one of the opposing surfaces (13, 19), journal bearing element 18 addition complicates the design with regards to tolerances. The invention described herein provides increased bearing precision and wear resistance over that of the prior art.

SUMMARY OF INVENTION

[0006] The disclosure herein provides embodiments of a journal bearing for use in a roller cone bit and includes a manner of attaching a journal bearing element onto the head section of a drill bit. The journal bearing element included herein may prevent rotation of the journal bearing element. For example, when the bearing is used in conjunction with a roller cone, the sliding surfaces will be on the outer circumference of the journal bearing element and the inner surface of the roller cone. Methods of adhering the journal bearing element to the head include welding, brazing, gluing, the use of pins or dowels, an interference or press fit, splines transverse to the journal bearing circumference, and keys or key ways formed for insertion between the journal bearing element and the head section. In one embodiment, the journal bearing element is fixed in place relative to the head section and may optionally be comprised of dense high purity powdered metal alloys with uniform micro-structure. These powdered metal alloys may optionally be of a class that contains vanadium. A second optional class of materials would include a cobalt-chromium-tungsten alloy with high carbon content.

BRIEF DESCRIPTION OF DRAWINGS

[0007] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0008] Figure 1 is a cross-sectional view of a portion of a roller cone bit.

[0009] Figure 2 is a view of a journal bearing element with a single separation.

[0010] Figure 3 is a sectional view of a bit body head section.

[0011] Figure 4 is a perspective view of an embodiment of a journal bearing portion of a head section consistent with the present disclosure.

[0012] Figure 5 is a view of a journal bearing element as embodied in the present disclosure.

[0013] Figure 6.is a perspective view of an embodiment of a journal bearing element coupled to a journal.

[0014] Figure 7 is a perspective partial sectional view of the embodiment of Figure 6.

[0015] Figure 8 is a perspective partial sectional view of a journal bearing element coupled to a journal.

[0016] Figure 9 is a perspective partial sectional view of a journal bearing element coupled to a journal.

[0017] Figure 10 is a sectional view of a bit body head section.

[0018] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

[0019] The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout.

[0020] It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

[0021] Figure 3 is a partial sectional view of an earth-boring bit 21 having a journal bearing element 28 as described herein. While Figure 3 only illustrates a single section, the bit 21 may comprise two or more sections welded together to form the composite bit 21. The earth-boring bit 21 has bit body 23 with a threaded upper portion 25 for connecting to a drill string member (not shown) and a leg section 22 having a cutting cone 41 attached thereon. A fluid passage 27 directs drilling fluid to a nozzle (not shown) that impinges drilling fluid against the borehole bottom to flush cuttings to the surface of the earth. A pressure compensating lubrication system 31 may optionally be contained within each section of the bit 21. A lubrication passage 33

extends downwardly to a ball plug 35, which is secured to the body 21 by a plug weld 37. A third lubrication passage (not shown) carries lubricant to a bearing surface between a bearing shaft 39, which is cantilevered downwardly and inwardly from an outer and lower region of the body 23 of the bit 21. The ball plug 37 retains a series of ball bearings 40 rotatably secured to the cutter cone 41 and to the bearing shaft 39. Dispersed in the cutter cone 41 are a plurality of rows of earth disintegrating cutting elements or teeth 42 securable by interference fit in mating holes of the cutter cone 41. An elastomeric O-ring seal 43 is received within a recess 44 formed in the journal bearing shaft 39.

[0022] Figure 4 provides a perspective view of an embodiment of a portion of the earth boring bit 21 of Figure 3. Figure 4 illustrates in more detail an example of a journal bearing portion of the leg section 22 in accordance with the present disclosure. The leg section 22 is shown in perspective view having the bearing shaft 39 which comprises a base for the cutter cone 41. The bearing shaft 39 includes a journal section 26 having a recess 44 circumscribing the outer circumference of the bearing shaft 39. The recess 44 includes a bearing surface 47 (Figure 3) on its lower surface formed to receive a journal bearing element 28 thereon. Adjacent the journal section 26 is a ball race 30 formed to receive the ball bearings 40 connecting the leg section 22 to the cutter cone 41. In this embodiment, the journal bearing element 28 is a cylindrical body having an inner surface 48 (Figure 3) that couples with the bearing surface 47. First and second lateral sides (45, 46) extend from the inner surface 48 and terminate at an outer surface 49. At least one separation 32 is shown along the circumference of the journal bearing element 28.

[0023] The journal bearing element 28 may be affixed to the journal section 26 by means of brazing, gluing, soldering, or welding either individually or in combination with other coupling

means as illustrated in Figure 5. Optionally, the journal bearing element 28 may comprise multiple sections or members. Each individual member is curvilinear and having a radius of curvature that circumscribes the bearing shaft 39 when the members are arranged around the bearing surface of the bearing shaft 39. Within the scope of this disclosure, the term coupling means joining the journal bearing element 28 to a bearing shaft 39 where some or no degrees of freedom exist between the element 28 and the bearing shaft 39. Thus coupling includes preventing the journal bearing element 28 from sliding within the recess 44 circumferentially around the bearing shaft 39 but yet allowing the journal bearing element 28 to be removed from the bearing shaft 39. Coupling also includes preventing relative sliding but allowing axial movement as well as totally affixing the journal bearing element 28 to the bearing shaft. Coupling a single member of a multi-member journal bearing element 28 to the bearing surface 47 within the recess 44 precludes the other members from sliding when adjacent members abut at a split section 32. Optionally, the journal bearing element 28, or the individual members, may also be coupled to prevent sliding in a lateral direction

[0024] Figure 6 illustrates an alternative coupling element embodiment for coupling a journal bearing element 28a to the bearing shaft 39; in this embodiment a dowel 34 is inserted through a bore 62 formed in the journal bearing element 28. Illustrated in a perspective partial sectional view in Figure 7, the bore 62 through the journal bearing element 28 registers with a corresponding bore 60 formed through the bearing surface 47 on the journal section 26. Figure 9 is a perspective partial sectional view of a coupling device comprising a key 36 that couples the journal bearing element 28 to the journal section 26. The key 36 is inserted into a passage formed by aligning a channel 56 in the journal bearing element 28 with a channel 54 formed in the journal section 26.

[0025] Another coupling device embodiment is presented in perspective partial sectional view in Figure 8. In this embodiment, a raised profile 38 having a semi-circular cross section is provided on the journal bearing element 28 inner circumference that protrudes into a similarly shaped indentation 52 on the journal section 26 outer circumference. Engaging the profile 38 with the indentation 52 couples the journal bearing element 28 with the journal section 26 to prevent circumferential sliding of the journal bearing element 28 over the journal section 26. The profile 38 and indentation 52 of Figure 8 are not limited to semi-circular embodiments, but can include rectangular, triangular, elliptical, and other shapes. It should be pointed out that coupling the journal bearing element 28 to the journal section 26 may allow lateral tilting of the journal bearing element 28 with respect to the journal section 26. For example, although coupled, one of the first lateral side 45 or second lateral side 46 may experience radial movement away from the journal section 26. The coupling devices described herein can be disposed proximate or at the first and second lateral sides (45, 46) of the journal bearing element 28. Optionally, a substantial portion of the indentation/profile, channel/key, and bore/dowel configurations may reside between the first and second lateral sides (45, 46).

[0026] Figure 5 provides a view of an embodiment of a multi-section journal bearing element 28. In this embodiment, the journal bearing element 28 comprises three sections abutted at split sections 32. Thus coupling at least one of the sections to a corresponding bearing shaft 39 prevents the remaining sections from circumferential sliding. Optionally, the use of silver plating on the inner circumference of a corresponding cone may be employed with the journal bearing element 28 described herein.

[0027] An optional embodiment of a journal bearing element 28a is provided in a side sectional view in Figure 10. The journal bearing element 28a illustrated comprises a single

circular member and mates over the journal section 26 outer diameter rather than in a recess. The bearing 28a is installed on the bit 21 by slipping it over the free end of the bearing shaft 39 and sliding the journal bearing element 28a adjacent the journal bearing surface 47. The journal bearing element 28a can be coupled to the journal section 26 in any of the above described manners.

[0028] The material used in making the journal bearing element 28 of the present device may be any suitable material; examples of materials include steels, stainless steels, and hard metal alloys including various Stellite® alloys. A material formed using a powdered metal manufacturing technique may be used for the journal bearing element 28. For example, a high vanadium content stainless steel powder could be used in conjunction with a powdered metal manufacturing technique to form a suitable bearing element. One specific example of this is an alloy referred to herein as S90V®, the alloy has carbon with a content of about 2.3% by weight of the alloy, a chromium content of about 14% by weight of the alloy, a vanadium content of about 9% by weight of the alloy, and molybdenum content of about 1% by weight of the alloy. Additionally, AISI 440C chemistries could be used to form a suitable head bearing element. For the purposes of the present disclosure, high vanadium content includes a composition, such as metal or metal powders having about 3% by weight or more of vanadium. Alternative values for vanadium content include 4%, 5%, 6%, 7%, 8% by weight, and all values of weight percentages between.

[0] Another set of powered metal alloys for use in making the journal bearing herein described includes a cobalt-chromium-tungsten-carbon alloy. Optionally, the alloy may have a carbon content of about 1.2% by weight or greater.

[0030] The powder compositions described herein may utilize "master melt" compositions wherein all particles have essentially the same chemistry. Using a solid state consolidation technique, such as sintered-hot-isostatic-pressing, maintains homogeneity of the final product thereby producing a solid material without voids.

[0031] Other bit components could be made from the compositions described herein. Those components include any load bearing surface within the roller cone bit including thrust surfaces; additionally, pilot pin elements could also be manufactured using the compositions cited herein.

We claim:

1. An earth boring bit comprising:

a bit body;

a leg section depending from the body;

a bearing shaft extending from the leg having a circular bearing surface having an indentation formed substantially aligned with the axis of the bearing shaft;

a coupling element disposed in the indentation;

a journal bearing element on the bearing shaft and joined to the coupling element thereby coupling the journal bearing element to the bearing shaft.

2. The earth boring bit of claim 1, wherein the coupling element comprises a raised profile formed on the journal bearing element inner surface and a corresponding indentation in the bearing shaft formed to receive the raised profile therein for coupling engagement between the journal bearing and the bearing shaft.

3. The earth boring bit of claim 1, wherein the indentation comprises a first channel formed in the bearing shaft surface, the coupling element comprises a key member extending from the first channel into a second channel formed in the inner surface of the journal bearing element.

4. The earth boring bit of claim 1, wherein the journal bearing element comprises at least two separate members disposed on the bearing shaft.

5. The earth boring bit of claim 4, wherein the members substantially circumscribe the bearing shaft circumference.

6. The earth boring bit of claim 5, wherein one of the journal bearing elements is coupled with a coupling element thereby preventing circumferential movement of each bearing member with respect to the bearing surface.

7. The earth boring bit of claim 1 further comprising a cone mounted for rotation on the bearing shaft, the cone including a mating bearing surface for engagement with the journal bearing element outer surface.

8. The earth boring bit of claim 1, wherein coupling the journal bearing element to the bearing shaft prevents circumferential sliding of the journal bearing element around the bearing shaft.

9. An earth boring bit comprising:

a bit body;

a leg section depending from the body;

a bearing shaft extending from the leg having a circular bearing surface; and

a journal bearing element formed separately from the bit and adhered to the bearing shaft.

10. The earth boring bit of claim 9, wherein the journal bearing element is adhered to the bearing shaft by a process selected from the group consisting of soldering, brazing, and gluing.

11. The earth boring bit of claim 9, wherein the journal bearing element comprises at least two separate members disposed on the bearing shaft.

12. The earth boring bit of claim 11, wherein the members substantially circumscribe the bearing shaft circumference.

13. The earth boring bit of claim 12, wherein one of the journal bearing elements adhered to the bearing shaft prevents circumferential movement of each of the other bearing members.

14. The earth boring bit of claim 9 further comprising a cone mounted for rotation on the bearing shaft, the cone including a mating bearing surface for engagement with the journal bearing element outer surface.

15. The earth boring bit of claim 9, wherein adhering the journal bearing element to the bearing shaft prevents circumferential sliding of the journal bearing element around the bearing shaft.

16. An earth boring bit comprising:

a bit body;

a leg section depending from the body;

a bearing shaft extending from the leg having a circular bearing surface; and

a journal bearing element comprising an alloy, wherein the alloy includes at least about 3% by weight of vanadium.

17. The earth boring bit of claim 16 wherein the alloy is formed from a stainless steel powder.

18. The earth boring bit of claim 16 wherein the vanadium content exceeds about 6% by weight of the alloy.

19. The earth boring bit of claim 16 wherein the vanadium content is at least about 9% by weight of the alloy.

20. The earth boring bit of claim 16 wherein the alloy comprises carbon with a content of about 2.3% by weight of the alloy, chromium with a content of about 14% by weight of the alloy, vanadium with a content of about 9% by weight of the alloy, and molybdenum with a content of about 1% by weight of the alloy.