A friction and/or torque reducing drillstring component has a one-piece mandrel body 5 with a mandrel body recess 13c considerably smaller than mandrel upper neck 13a and mandrel body lower neck 13b, dressed with an outer sleeve 18 which is interlocked with a two-piece inner bearing 20 through several integral dove-tailed splines 22b and grooves 22a. The combination of the outer sleeve 18 and inner bearing 20 is restricted in vertical movement over the said mandrel body 5 by an integral, optionally spirally, bladed first stop 15 and a removable second stop 16. The removable second stop 16 is locked onto the mandrel body upper neck 13a by means of threaded retaining bolts 24. Once the second stop 16 is removed, the one-piece outer sleeve 18 is retractable over the mandrel body upper neck 13a to allow the removal of the two-piece inner bearing 20. A second inner bearing 155 may also be provided.
Fig. 24
FRICION REDUCING DRILLSTRING COMPONENT

[0001] This invention relates to equipment used on a drillstring to reduce the rotational friction between the rotating drillstring and the borehole wall. The said equipment is particularly useful in the oil, gas and mining industries especially, but not exclusively, for drilling of high angle, horizontal and extended reach wells.

BACKGROUND OF THE INVENTION

[0002] In order to drill a well, a drillstring is assembled above a drill bit. The drillstring is used to transfer the rotary motion from the surface equipment to the drill bit, thereby causing the drill bit to rotate and penetrate the sub surface formation. However, the torque required at surface to rotate the drill bit is substantially increased due to the friction caused by contact between the drillstring and the wall of the borehole. Furthermore, the rotational contact between the drillstring and the borehole wall causes wear on drillstring as well as causing damage and wear to the steel cased section of the borehole wall. Conventionally, the drilling process also involves pumping of drilling fluid down the bore through the inside diameter of the drillstring to improve the drilling performance of the bit, to assist with cooling and lubrication of the bit as well as providing the means to transfer the drill cuttings to surface. Conveyance of the drill cuttings is a function of well depth, well profile, shape and size of drill cuttings, mechanical properties of the drilling fluid and the capacity of surface mud pumps.

[0003] Conventional friction reducing drill pipe components are shown, for example, in UK Patent nos. 229598 and 2304763.

SUMMARY OF THE INVENTION

[0004] As those skilled in the art will appreciate, an accumulation of drill cuttings in the well bore is a major obstacle in any drilling operation as it can increase downhole friction, thus increasing the amount of torque required, and in some instances can lead to the drillstring getting stuck in hole. For these reasons, efficient drilling fluid circulation is essential.

[0005] According to the present invention, there is provided a component for forming part of a drill string, the component comprising a mandrel having couplings for connection with the drill string, a bearing member mounted on the mandrel and a sleeve member mounted on the bearing member.

[0006] Preferably, the bearing member is an inner bearing member, and the sleeve member is an outer sleeve member.

[0007] Preferably, the component further comprises first and second retaining members for retaining the inner bearing member, and the outer sleeve member on the mandrel. Typically, the retaining members also prevent longitudinal movement of the inner bearing member, and the outer sleeve member, on the mandrel. Typically, at least one of the first and second retaining members is removable or retractable from the mandrel, and more preferably, is removable or retractable from the mandrel to permit the inner bearing member, and the outer sleeve member, to be removed from the mandrel. Most preferably, one of the first and second retaining members is removable from the mandrel by removing one or more fixture devices, and typically, the other of the first and second retaining members is integral with the mandrel.

[0008] Preferably, the inner bearing member is provided in at least two portions, the portions preferably when brought together forming a substantially tubular member. More preferably, there are two portions, each portion comprising a half cylindrical member. Preferably, the at least two portions are mounted in a recess of the mandrel, the recess comprising a reduced diameter portion with its diameter less than the diameter of the drill string, and particularly to the diameter of the joints of the drill string. Typically, the outer sleeve member is arranged coaxially with the inner bearing member in use of the component, and preferably, a selective locking mechanism is provided to prevent relative rotational movement between the inner bearing member and the outer sleeve member in use of the component. The selective locking mechanism may comprise a first locking device provided on the inner bearing member and a second locking device provided on the outer sleeve member. Preferably, the first locking device is provided on the outer surface of the inner bearing member and the second locking device is provided on the inner surface of the outer sleeve member. More preferably, the first and second locking devices interact with one another to provide the locking action. Typically, the first and second locking devices are formations provided on the respective surfaces of the inner bearing member and outer sleeve member, and more preferably, the formations are arranged longitudinally at least partly along the length of the respective inner bearing member and outer sleeve member. Optionally, a third locking device, which may be in the form of a key, may be provided to interact with the first and second locking devices to provide the locking action.

[0009] Preferably, the component further comprises a second inner bearing member which is typically provided in at least two portions, the portions preferably when brought together forming a substantially tubular member. More preferably, there are two portions, each portion comprising a half cylindrical member. Preferably, the at least two portions are mounted in the same recess of the mandrel that the two portions of the first inner bearing member are mounted. Preferably, the first and second bearing members each comprise a device which separates the outer sleeve member from the mandrel. Typically the separating device is a flange.

[0010] Preferably, the first inner bearing member is capable of rotation with respect to the second inner bearing member.

[0011] Preferably, a selective locking mechanism is provided to prevent relative rotational movement between the second inner bearing member and one of the first and second retaining members in use of the component. The selective locking mechanism may comprise a first locking device provided on the second inner bearing member and a second locking device provided on the said one of the retaining members. Preferably, the first locking device is provided on the outer surface of the second inner bearing member and the second locking device is provided on the inner surface of the said one of the retaining members. More preferably, the first and second locking devices interact with one another to provide the locking action. Typically, the first and second locking devices are formations provided on the respective
surfaces of the second inner bearing member and said one of the retaining members, and more preferably, the formations are arranged longitudinally at least partly along the length of the respective second inner bearing member and said one of the retaining members. Optionally, a third locking device, which may be in the form of a key, is provided to interact with the first and second locking devices to provide the locking action.

[0012] Preferably, the outer sleeve member is a one-piece outer sleeve member. Preferably, the mandrel is a one-piece or unitary mandrel body.

[0013] The component may be dismantled by removing one of the retaining devices and removing, if present, the second inner bearing member, and then removing the outer sleeve member over one end of the mandrel, and then removing the first inner bearing member. A section of the mandrel directly above and/or below the first and/or second retaining member may be spirally milled and fluted to provide integral spiral blades.

[0014] Preferably, the mandrel, stops, outer sleeve member, inner bearing member(s) and the retaining devices are made of steel, but the inner bearing member(s) and/or outer sleeve member may also be made from high temperature/high impact/wear resistant ceramics, such as alumina ceramic, polymers or metals other than steel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0016] FIG. 1 shows a cross sectional view of a mandrel body forming part of a first embodiment of the present invention;

[0017] FIG. 2 shows a side view of the mandrel body of FIG. 1 provided with an outer sleeve member and a pair of inner bearing members together forming the first embodiment of the present invention;

[0018] FIG. 3 shows a cross-sectional plan view through section 3-3 of the mandrel body, outer sleeve member and inner bearing member of FIG. 2;

[0019] FIG. 4 shows a cross-sectional plan view through section 4-4 of the mandrel body, and second retaining member of FIG. 2;

[0020] FIG. 5 shows a cross sectional view of a mandrel body forming part of a second embodiment of the present invention;

[0021] FIG. 6 shows a side view of the mandrel body of FIG. 5;

[0022] FIG. 7 shows a plan view through section C-C of the mandrel body of FIG. 6;

[0023] FIG. 8 is a cross sectional view of one of a pair of first inner bearing members for mounting on the mandrel body of FIG. 5;

[0024] FIG. 9 is a side view of the one first inner bearing member of FIG. 8;

[0025] FIG. 10 is a first end view of the one first inner bearing member of FIG. 8;

[0026] FIG. 11 is a second end view of the one first inner bearing member of FIG. 8;

[0027] FIG. 12 is a side view of one of a pair of second inner bearing members for mounting on the mandrel body of FIG. 5;

[0028] FIG. 13 is a cross sectional view of the one second inner bearing member of FIG. 12;

[0029] FIG. 14 is a first end view of the one second inner bearing member of FIG. 12;

[0030] FIG. 15 is a second end view of the one second inner bearing member of FIG. 12;

[0031] FIG. 16 is a side view of a locking ring for mounting on the mandrel body of FIG. 5;

[0032] FIG. 17 is a first end view of the locking ring of FIG. 16;

[0033] FIG. 18 is a second end view of the locking ring of FIG. 16;

[0034] FIG. 19 is a side view of an outer sleeve for mounting on the mandrel body of FIG. 5;

[0035] FIG. 20 is a side view of a cross section through the outer sleeve of FIG. 19;

[0036] FIG. 21 is a first end view of the outer sleeve of FIG. 19;

[0037] FIG. 22 is a side view of a rectangular longitudinal groove formed on the inner bore of the outer sleeve of FIG. 19;

[0038] FIG. 23 is a plan view of a cross section through the outer sleeve of FIG. 19; and

[0039] FIG. 24 shows a side view of a cross section through the mandrel body of FIG. 5 provided with an outer sleeve member and a pair of first inner bearing members and a pair of second inner bearing members together forming the second embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0040] A mandrel body 5 forming part of a first embodiment of a friction reducing drill string component 1 in accordance with the present invention is shown in FIG. 1. The mandrel body 5 comprises a male pin end 10 and female box end 11, both of which 10, 11 are provided with standard API screw threads to permit the mandrel body 5 to be included in a drill string (not shown). The mandrel body 5 further comprises a mandrel bore 12, mandrel body upper neck 13a, mandrel body lower neck 13b and a mandrel body recess 13c; a threaded bore 14 and an integral first stop 15. Accordingly, the mandrel body 5 is a one-piece component. It should be noted that the first stop 15 may be lengthened, and also that the first stop may be spirally milled on it’s outer surface to form integral blades proposed for hydra-mechanical and hydra-dynamic drill cuttings bed removal.

[0041] FIG. 2 illustrates the assembly arrangement of an outer sleeve 21, inner bearing members 20 and retaining systems 15, 16 in place on the mandrel body 5 to form the friction reducing drill string component 1 in accordance with the present invention. Also shown in FIG. 2 are a removable second stop 16 having circular access ports 17, a one piece
outer sleeve 18 which is preferably provided with straight or spiral blades 21, a two-piece inner sleeve 20 flanged at it’s lower end, longitudinal dove-tailed grooves 22a formed on the inner surface of the outer sleeve 18, and longitudinal dove-tailed integral splines 22b formed on the outer surface of the inner bearing members 20. The second stop 16 is in the form of an annular ring 16. It should be noted that the dove-tailed splines 22b and grooves 22a preferably do not extend the entire length of the sleeves.

[0042] As shown in FIGS. 2 and 3, the inner bearing members 20 are formed from two half-cylinder shaped inner bearings 20a and 20b.

[0043] In order to assemble the friction reducing drill string component 1, the inner bearing members 20a, 20b and are positioned around the mandrel body 5 within the mandrel body recess 13c, such that the flange is arranged at the lower in use end of the component 1.

[0044] Thereafter, the one piece outer sleeve 18 is slid over the mandrel body upper neck 13a. After lining up the dove-tailed grooves 22a with the dove-tailed splines 22b, outer sleeve 18 will slide over the inner bearing members 20 in a downward sliding manner until the lower end of the outer sleeve is rests directly on top of the flanged end of the inner bearing members 20. The second stop 16 is then slid over the mandrel body upper neck 13a and is lowered downwardly toward the outer sleeve 18 until each access port 17 lines up with it’s corresponding threaded bore 14. The second stop 16 is then secured on mandrel body upper neck 13a as illustrated in FIG. 4.

[0045] As shown in FIG. 3, the dove-tailed fitting arrangement of the outer sleeve 18 over the inner bearing members 20 prevents relative circumferential movement between the inner bearing members 20 and the outer sleeve 18.

[0046] As shown in FIG. 4, the second stop 16 is secured to the mandrel body upper neck 13a by means of a number of threaded retaining bolts 24 protruding through the respective circular access port 17, fitted and screwed into each corresponding threaded bore 14 and tightened to a specified torque. A locking clip 26 is then fitted into a locking clip recess 25 on each circular access port 17, this being a secondary safety measure to prevent the threaded locking bolt 24 from accidental unwinding and disengagement.

[0047] When the outer sleeve 18 and inner bearing members 20a, 20b are mounted on the mandrel body 5, and secured in position by the retaining devices 16, 15, the outside diameter of the outer sleeve 18 is sufficiently greater than the outside diameter of the drill pipe tool joints (not shown) which form the rest of the drill string. In this manner, when the friction reducing drill string component 1 is installed in the drill string, only the outer surface of the outer sleeve 18 will contact the wellbore wall and the drill pipe tool joint is not in contact with the wellbore wall. During the rotary drilling operation, the outer sleeve 18 is in contact with the bore wall and does not rotate whilst the mandrel body 5 rotates with the drillstring. Therefore there will be no rotational contact between the drillstring and the wellbore wall, and this ensures the protection of drillstring as well as the steel cased section of the well against damage and wear. On the other hand, the outside diameter of the mandrel body recess 13c here referred to as ‘d’ is smaller than the outside diameter of drill pipe tool joint here referred to as ‘D’. Hence, in rotary drilling mode the rotary surface contact circumference of the drillstring is effectively reduced by π(D−d). In other words, the torque or friction created is reduced. In addition, the first embodiment of the component 1 has the advantage that the pair of inner bearing members 20 can be formed from a different, and preferably less expensive material, than the outer sleeve 18 and in this manner, the inner bearing members 20 can be designed to be sacrificed and replaced when required.

[0048] Referring now to FIGS. 5 to 24, a mandrel body 105 forming part of a second embodiment of a friction reducing drill string component 100 in accordance with the present invention is shown in FIG. 5. The mandrel body 105 again comprises a male pin end 110 and female box end 111 in a similar fashion as the mandrel 5. The mandrel body 105 also comprises a mandrel bore 112, mandrel body upper neck 113a, mandrel body lower neck 113b and a mandrel body recess 113c, a number of threaded bores 114 and an integral first stop 115. It will be noted that the integral first stop 115 formed in the mandrel body 105 is above the mandrel body recess 113c, whereas the integral first stop 15 formed in the mandrel body 5 of the first embodiment is below the mandrel body recess 113c. Accordingly, the mandrel body 105 is again a one-piece component. The first stop 115 is spirally milled on its outer surface to form integral blades 150 for hydra-mechanical and hydra-dynamic drill cuttings bed removal.

[0049] FIG. 24 illustrates the assembly arrangement of an outer sleeve 121, a pair of first inner bearing members 120 flanged at their upper ends, a pair of second inner bearing members 155 flanged at their upper ends and retaining systems 115, 116 in place on the mandrel body 105 to form the friction reducing drill string component 100 in accordance with the second aspect of the present invention. Also shown in FIG. 24 is a removable second stop 116 having circular access ports 117 (shown in FIGS. 16 to 18), a one piece outer sleeve 118 which is provided with spiral, blades 121, longitudinal rectangular shaped grooves 122a formed on the inner surface of the outer sleeve 118, and longitudinal rectangular grooves 122b formed on the outer surface of the first pair of inner bearing members 120, and longitudinal rectangular grooves 122c formed on the outer surface of the second pair of inner bearing members 155. The second stop 116 is in the form of an annular ring 116, and is provided with longitudinal rectangular grooves 122d formed on its outer surface. It should also be noted that the rectangular grooves 122a, 122b, 122c and 122d preferably do not extend the entire length of the respective outer sleeve 118, first pair of inner bearing members 120, second pair of inner bearing members 155 and second stop 116.

[0050] As shown in FIGS. 8 to 11, the first pair of inner bearing members 120 are formed from two half-cylinder shaped inner bearings 120, and as shown in FIGS. 12 to 15, the second pair of inner bearing members 155 are formed from two half-cylinder shaped inner bearings 155.

[0051] In order to assemble the friction reducing drill string component 100, the first pair of inner bearing members 120 are positioned around the mandrel body 105 within the mandrel body recess 113c, such that the flange is arranged at the upper in use end of the component 100. A rectangular longitudinal key (not shown) is then placed into each groove 122d of the first pair of inner bearing members 120.
Thereafter, the one piece outer sleeve 118 is slid over the mandrel body lower neck 113b. After lining up the rectangular grooves 122a with the rectangular longitudinal keys, the outer sleeve 118 is slid over the inner bearing members 120 in an upward sliding manner until the upper end of the outer sleeve 118 rests directly against the underside of the flanged end of the first pair of inner bearing members 120.

The second pair of inner bearing members 155 are then positioned around the mandrel body 105 within what is left open of the mandrel body recess 113c, such that the flange of the second pair of inner bearing members 155 is arranged at the lower end of the outer sleeve 118 and the first pair of inner bearing members 120.

A rectangular longitudinal key (not shown) is then placed into each groove 122c of the second pair of inner bearing members 155.

The second stop 116 is then slid over the mandrel body lower neck 113b and, after lining up the rectangular grooves 122d with the rectangular longitudinal keys, the second stop 116 is slid over the second pair of inner bearing members 155 in an upward sliding manner toward the flange of the second pair of inner bearing members 155 until each access port 117 lines up with its corresponding threaded bore 114. The second stop 116 is then secured on mandrel body lower neck 113b with suitable threaded retaining bolts (not shown) and associated locking clips (not shown).

As shown in FIG. 5, the mandrel body 115 is provided with a further circumferential groove or recess 113d, around which a metal circlip (not shown) may be fitted. This further metal circlip and recess 113d provides a tertiary safety mechanism to prevent the dislodgement of the second retaining system (in the form of the second stop 116) if the primary safety mechanism (in the form of the bolts) and secondary safety mechanism (in the form of the associated locking clips) were to fail.

The rectangular fitting arrangement between the grooves 122a of the outer sleeve 118, the rectangular keys and the grooves 122b of the first pair of inner bearing members 120 prevents relative circumferential movement between the first pair of inner bearing members 120 and the outer sleeve 118. Also, the rectangular fitting arrangement between the grooves 122d of the second stop 116, the rectangular keys and the grooves 122c of the second pair of inner bearing members 155 prevents relative circumferential movement between the second pair of inner bearing members 155 and the second stop 116.

Accordingly, the second embodiment of the component 100 has the advantage that the first 120 and second 155 pairs of inner bearing members can be formed from a different, and preferably less expensive material, than the outer sleeve 118 and in this manner, the first 120 and second 155 pairs of inner bearing members can be designed to be sacrificed and replaced when required. In addition, when the outer sleeve 121 contacts the wellbore wall, no portion of the mandrel 115 is in direct contact with the outer sleeve 118, and since the outer sleeve 118 is preferably formed from a relatively hard wearing material, the lifespan of the mandrel body 115 is increased. In addition, it is only the first 120 and second 155 pairs of inner bearing members that provide the bearing surfaces with the mandrel 115, and so the material from which they are formed can be chosen to be less likely to damage the mandrel body 115. In other words, it is only the first 120 and second 155 pairs of inner bearing members that are in direct contact with the mandrel body 115 and the outer sleeve 121 is not in direct contact with the mandrel body 115.

Thus, the embodiments of the present invention provide a robust, fail safe mechanical, non-rotating stand-off on the drillstring so as to remove the rotational contact between the drillstring and the bore wall and therefore prevent damage or wear of drillstring and the cased section of the bore. The embodiments described herein also provide a means to reduce the rotational friction surface area of the drillstring, and therefore reduce the torque required to rotate the drill string at the surface. Furthermore, the embodiments described herein also provide a combined hydraulic and hydra-dynamic means of agitating the cuttings bed in order to improve the drilling fluid circulation.

Furthermore, the embodiments of the present invention provide the advantage that they allow for removal of the outer sleeve 18, 118 without dismantling of the mandrel body 5, 115 or outer sleeve 18, 118 or heat expansion of the outer sleeve 18, 118 and yet allow the effective inside diameter of the rotatable part of the component 1; 100 that is the combination of the inner bearing member 20, 120 and the outer sleeve 18, 118 to be smaller than the outside diameter of the upper and lower ends of the mandrel body 5, 115, hence providing a smaller bearing surface area between the inner bearing member 20, 120 and the mandrel body 5, 115 which results in lowered friction and torque. These features make the embodiments of the present invention a fail safe, easy to disassemble and reassemble drillstring component 1; 100 which reduces drilling torque due to the reduced friction surface area between the rotatable part of the component 1; 100 (the combination of the inner bearing member 20; 120 and the outer sleeve 18; 118) and the mandrel body 5; 115.

Modifications and improvements may be made to the embodiments hereinafter described without departing from the scope of the invention. For instance, the mandrel body 5; 115 may take the form of a full length (range 1 being 20 foot in length, range 2 being 31 foot in length or range 3 being 40 foot in length) drillpipe (not shown), or may take the form of drillpipe pup joints (not shown) of any length.

I claim:

1. A component for forming part of a drill string, the component comprising a mandrel having couplings for connection with the drill string, a bearing member mounted on the mandrel and a sleeve member mounted on the bearing member.

2. A component as claimed in claim 1, wherein the bearing member is an inner bearing member, and the sleeve member is an outer sleeve member, and the component further comprises first and second retaining members for retaining the inner bearing member, and the outer sleeve member, on the mandrel.

3. A component as claimed in claim 2, wherein at least one of the first and second retaining members is removable or retractable from the mandrel, to permit the inner bearing member, and the outer sleeve member, to be removed from the mandrel.
4. A component as claimed in claim 2, wherein the inner bearing member comprises at least two portions, which when brought together, form a substantially tubular member.

5. A component as claimed in claim 4, wherein the at least two portions are mounted in a recess of the mandrel, the recess comprising a reduced diameter portion with reference to the diameter of the drill string.

6. A component as claimed in claim 2, wherein the outer sleeve member is arranged coaxially with the inner bearing member in use of the component.

7. A component as claimed in claim 6, wherein a selective locking mechanism is provided to prevent relative rotational movement between the inner bearing member and the outer sleeve member in use of the component.

8. A component as claimed in claim 7, wherein the selective locking mechanism comprises a first locking device provided on the inner bearing member and a second locking device provided on the outer sleeve member.

9. A component as claimed in claim 8, wherein the first locking device is provided on the outer surface of the inner bearing member and the second locking device is provided on the inner surface of the outer sleeve member.

10. A component as claimed in claim 8, wherein the first and second locking devices interact with one another to provide the locking action.

11. A component as claimed in claim 10, wherein the first and second locking devices are formations provided on the respective surfaces of the inner bearing member and outer sleeve member.

12. A component as claimed in claim 11, wherein the formations are arranged longitudinally at least partly along the length of the respective inner bearing member and outer sleeve member.

13. A component as claimed in claim 10, wherein a third locking device is provided to interact with the first and second locking devices to provide the locking action.

14. A component as claimed in claim 2, further comprising a second inner bearing member comprising at least two portions.

15. A component as claimed in claim 14, wherein the portions when brought together form a substantially tubular member.

16. A component as claimed in claim 15, wherein there are two portions, each portion comprising a half cylindrical member.

17. A component as claimed in claim 14, wherein the at least two portions are mounted in the same recess of the mandrel that the two portions of the first inner bearing member are mounted.

18. A component as claimed in claim 14, wherein the first and second bearing members each comprise a device which separates the outer sleeve member from the mandrel.

19. A component as claimed in claim 14, wherein the first inner bearing member is capable of rotation with respect to the second inner bearing member.

20. A component as claimed in claim 14, wherein a selective locking mechanism is provided to prevent relative rotational movement between the second inner bearing member and one of the first and second retaining members in use of the component.

21. A component as claimed in claim 2, wherein the outer sleeve member is a one-piece outer sleeve member.

22. A component as claimed in claim 2, wherein the component is dismantled by removing one of the retaining devices and removing, if present, the second inner bearing member and then removing the outer sleeve member over one end of the mandrel, and then removing the first inner bearing member.

23. A component as claimed in claim 1, wherein a section of the mandrel directly above and/or below the first and/or second retaining member comprises spiral blades.

24. A component as claimed in claim 1, wherein the mandrel is a one-piece mandrel body.