

METHOD AND APPARATUS FOR REDUCING STICK-SLIP IN DRILLING OPERATIONS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to United States Provisional Application No. 61/583,468, filed on January 5, 2012, entitled "Method and Apparatus for Reducing Stick Slip in Drilling Operations", which is herein incorporated by reference in its entirety.

BACKGROUND

The present disclosure relates generally to downhole drilling operations and, more particularly, to stabilizing downhole tools from lateral vibration and borehole contact.

Typical subterranean drilling apparatuses include stabilizers with stabilizer blades that contact the borehole wall and prevent lateral movement of the drilling apparatus within the borehole. Unfortunately, the stabilizer blades can become caught or lodged in the borehole wall, causing the drill string to "stick". When the drilling apparatus "sticks", the rotational movement of the drill string is either stopped or severely decreased. Torque is still imparted to the drill string at the surface, despite the stabilizer being stuck, causing the drill string to twist. Once the torque applied to the drill string overcomes the force of friction on the stabilizer blades, the drill string "slips" or releases from the borehole wall. This configuration is problematic because it decreases the lifespan of downhole components, it decreases the quality of the borehole, and it requires large amounts of torque to "slip" the drill string.

SUMMARY OF INVENTION

According to a first aspect of the present invention, there is provided an apparatus for reducing stick-slip in drilling operations, comprising: a cylindrical tool body; a first roller disposed on an outer surface of the cylindrical tool body at a first location, and comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates; and a second roller disposed on the outer surface of the cylindrical tool body at a second location, and comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body.

According to a second aspect of the present invention, there is provided a method for reducing stick-slip in drilling operations, comprising: coupling a downhole tool to a drilling string, wherein the downhole tool comprises a cylindrical tool body; a first roller disposed on an outer surface of the cylindrical tool body at a first location, and comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates; and a second roller disposed on the outer surface of the cylindrical tool body at a second location, and comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body; and positioning the downhole tool within a borehole.

According to a third aspect of the present invention, there is provided a method for manufacturing a downhole tool for reducing stick-slip in drilling operations, comprising: positioning a first roller on an outer surface of a cylindrical tool body at a first location, the first roller comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates; and positioning a second roller on the outer surface of the cylindrical tool body at a second location, the second roller comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features.

Figure 1 depicts an example drilling system, according to aspects of the present disclosure.

Figures 2A-2C depict an example downhole tool, in accordance with certain embodiments of the present disclosure.

Figure 3 depicts an example downhole tool, in accordance with certain embodiments of the present disclosure.

While embodiments of this disclosure have been depicted and described and are defined by reference to exemplary embodiments of the disclosure, such references do not imply a limitation on the disclosure, and no such limitation is to be inferred. The subject matter disclosed is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those skilled in the pertinent art and having the benefit of this disclosure. The depicted and described embodiments of this disclosure are examples only, and not exhaustive of the scope of the disclosure.

DETAILED DESCRIPTION

The present disclosure relates generally to downhole drilling operations and, more particularly, to stabilizing downhole tools from lateral vibration and borehole contact.

Illustrative embodiments of the present invention are described in detail below. In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of the present disclosure.

To facilitate a better understanding of the present disclosure, the following examples of certain embodiments are given. In no way should the following examples be read to limit, or define, the scope of the disclosure. Embodiments of the present disclosure may be applicable to horizontal, vertical, deviated, multilateral, u-tube connection, intersection, bypass, or otherwise nonlinear wellbores in any type of subterranean formation. Embodiments may be applicable to injection wells, and production wells, including natural resource production wells such as hydrogen sulfide, hydrocarbons or geothermal wells; as well as borehole construction for river crossing tunneling and other such tunneling boreholes for near surface construction purposes or borehole u-tube pipelines used for the transportation of fluids such as hydrocarbons. Embodiments described below with respect to one implementation are not intended to be limiting.

Modern petroleum drilling and production operations demand information relating to parameters and conditions downhole. Several methods exist for downhole information collection, including logging while drilling ("LWD") and measurement-while drilling ("MWD"). In LWD, data is typically collected during the drilling process, thereby avoiding any need to remove the drilling assembly to insert a wireline logging tool. LWD consequently allows the driller to make accurate real-time modifications or corrections to optimize performance while minimizing down time. MWD is the term for measuring conditions downhole concerning the movement and location of the drilling assembly while the drilling continues. LWD concentrates more on formation parameter measurement. While distinctions between MWD and LWD may exist, the terms MWD and LWD often are used interchangeably. For the purposes of this disclosure, the term LWD will be used with the understanding that this term encompasses both the collection of formation parameters and the collection of information relating to the movement and position of the drilling assembly.

Fig. 1 illustrates an example drilling system 100, according to aspects of the present disclosure. The drilling system 100 comprises a rig 101 positioned at the surface 102, above a formation 103. Although the rig 101 is shown on land in Fig. 1, the rig 101 may be used at sea, with the surface 102 comprising a drilling platform. The rig 101 may be coupled to a drilling assembly 104 that is drilling a borehole 105 within the formation 103. The drilling assembly 104 may comprise a drill string 106 and a bottom hole assembly (BHA) 107. The BHA 107 may comprise a stabilizer 108 and one or more LWD or MWD systems 109 and 110. The LWD/MWD systems 109 and 110 may comprise downhole instruments. While drilling is in progress these instruments may continuously or intermittently monitor predetermined drilling parameters and formation data and transmit the information to a surface detector by some form

of telemetry. Alternatively, the data can be stored while the instruments are downhole, and recovered at the surface later when the drill string is retrieved.

The stabilizer 108 in the BHA 107 may contact the borehole wall and prevent lateral movement of the BHA 107 within the borehole 108. Typical stabilizers may comprise fixed blades that can become caught or lodged in the borehole wall 105, causing the drill string 106 to “stick”. When the drill string “sticks”, the rotational movement of the drill string 106 is either stopped or severely decreased. Torque may still be imparted to the drill string 106 from the rig 101, despite the stabilizer 108 being stuck, causing the drill string 109 to twist. Once the torque overcomes the force of friction on the stabilizer 108, the drill string 106 may “slip” or release from the borehole wall 105. This “slip” and “stick” action may decrease the lifespan of downhole components, including LWD/MWD measurement elements 109 and 110, and decrease the quality of the borehole 105.

Figs. 2A and 2B depict an example downhole tool, stick-slip reducer (“SSR”) 200, that may be used as the stabilizer 108, in accordance with aspects of the present disclosure. As will be appreciated by one of ordinary skill in the art in view of this disclosure, the SSR 200 may be included within a BHA in various positions, and also may be coupled to a drill string at a location that is apart from the BHA. The SSR 200 may comprise a cylindrical tool body 201 that defines an internal bore 202. In certain embodiments, the cylindrical tool body 201 may be non-magnetic, which may allow the SSR 200 to be used in conjunction with directions sensors in a BHA. Advantageously, if the SSR 200 body 201 is non-magnetic, the SSR 200 may not interfere with the directional sensors, and the directional sensors may be positioned close to the SSR 200. This may afford greater protection to the directional sensors against lateral vibration and wall contact.

In certain embodiments, the SSR 200 may be included within a BHA using one or both of the box and pin connections 203 and 204. The SSR 200 may also be included within a drill string apart from the BHA. Additionally, as would be appreciated by one of ordinary skill in view of this disclosure, the SSR 200 may be included within a BHA or drill string with other connections mechanisms known in the art.

The SSR 200 may comprise a first roller 205 disposed on an outer surface of the cylindrical tool body 201 at a first location 206. The SSR 200 may also comprise a second roller 207 disposed on the outer surface of the cylindrical tool body 201 at a second location 208. The second location 208 may be offset from the first location 206 both laterally and circumferentially with respect to a longitudinal axis 209 of the cylindrical tool body 201. The rollers 205 and 207 may comprise elongated structures parallel to the longitudinal axis 209 of the cylindrical tool body 201. Other roller embodiments are possible, including but not limited to spherical rollers.

In certain embodiments, the SSR 200 may comprise a third roller 210 disposed on the outer surface of the cylindrical tool body 201 at a third location 211. The third location 211 may be offset from the first location 206 and the second location 208 both laterally and circumferentially with respect to a longitudinal axis 209 of the cylindrical tool body 201. Although SSR 200 includes three rollers at three different lateral and circumferential locations, this configuration is not meant to be limiting. For example, certain embodiments may include less than three rollers or more than three rollers, each offset laterally and circumferentially. Likewise, certain embodiments may include less than three roller or more than three rollers, with only some of the rollers offset laterally and circumferentially. Other variations would be appreciated by one of ordinary skill in the art in view of this disclosure.

In certain embodiments, the SSR 200 may include a first cavity 212 within the cylindrical tool body 201, in which the first roller 205 may be partially disposed. The SSR 200 may also include a second cavity 213, in which the second roller 207 may be partially disposed. The first cavity 212 and second cavity 213 may be located at the first location 206 and second location 208, respectively. In certain embodiments, the SSR may also include a third cavity 214 corresponding to the third location 211, in which the third roller 210 is partially disposed.

To accommodate communications and drilling fluid flow through the SSR 200, a feedthrough may be disposed within the internal bore 202. Fig. 3 illustrates an example slim feedthrough 300, which may be inserted coaxially within the SSR 200. The slim feedthrough 300 may include a sealed cylindrical pathway 301 through which communication between MWD/LWD sensors above and below the SSR 200 may be accomplished. The communication may be accomplished, for example, by wires within the cylindrical pathway 301 of the SSR 300. Notably, because of the volume displaced within the SSR 200 by the slim feedthrough 300 may be relatively low, the flow pressure through the SSR 200 may not be dramatically decreased.

In certain embodiments, the thickness of the cylindrical tool body 201 of the SSR 200 may be increased, allowing the depth of the cavities to be increased to accommodate larger rollers. Notably, if the slim feedthrough 300 is used, the thickness of the cylindrical tool body 201 of the SSR 200 may be increased without large sacrifices in flow area through internal bore 202. With the thickness of the cylindrical tool body 201 increased, the SSR 200 may accommodate rollers with a larger diameter, which are typically used for larger boreholes. In certain embodiments, for example, the SSR 200 may be sized to accommodate rollers typically used in a 9 7/8 inch borehole, even though the SSR 200 may be intended for use in an 8 1/2 inch borehole. In certain other embodiments, the rollers may comprise XDrilling Tools WedgeTail™

roller technology, which provide for longer bearing life. More robust and larger rollers, such as 9 7/8 inch XDrilling Tools WedgeTail™ may reduce the maintenance costs of the SSR 200.

As will be appreciated by one of ordinary skill in the art in view of this disclosure, the SSR 200 with slim feedthrough 300 may replace a typical stabilizer with blades, and eliminate the wall contact of the stabilizer blades, which cause sticking. The staggered rollers of the SSR 200 may allow the drill string to rotate freely without the additional torque necessary to “slip” the drill string. The SSR 200 may also dampen MWD/LWD sensors from damaging lateral vibration, as the rollers of the SSR 200 may contact the borehole wall, preventing such vibration. Moreover, with the rollers staggered laterally on the face of the SSR 200, both the interior flow area of the SSR 200 and the exterior flow area between the SSR 200 and the borehole may be preserved. Additionally, the staggered placement may also provide a larger contact area between the SSR 100 and the borehole wall, allowing for better stabilization, prevention of lateral vibration, and prevention of wall contact by adjacent MWD/LWD tools and sensors.

According to aspects of the present disclosure, an example method for reducing stick-slip in drilling operations may comprise coupling a downhole tool to a drill string. The downhole tool may comprise a cylindrical tool body, a first roller disposed on an outer surface of the cylindrical tool body at a first location, and a second roller disposed on the outer surface of the cylindrical tool body at a second location. The second location may be offset laterally and circumferentially from the first location on the cylindrical body. The method may further include positioning the downhole tool within a borehole.

According to aspects of the present disclosure, an example method for manufacturing a downhole tool for reducing stick-slip in drilling operations may comprise

providing a cylindrical tool body. The method may also comprise positioning a first roller on an outer surface of the cylindrical tool body at a first location, and positioning a second roller on the outer surface of the cylindrical tool body at a second location. The second location may be offset laterally and circumferentially from the first location on the cylindrical tool body. In certain embodiments, the cylindrical tool body may comprise a first cavity and a second cavity, and positioning the first and second rollers may comprise disposing the first roller and second roller within the first and second cavities respectively.

Therefore, the present invention is well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular embodiments disclosed above are illustrative only, as the present invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular illustrative embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the present invention. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. The indefinite articles “a” or “an,” as used in the claims, are each defined herein to mean one or more than one of the element that it introduces.

WHAT IS CLAIMED IS:

1. An apparatus for reducing stick-slip in drilling operations, comprising:
a cylindrical tool body;
a first roller disposed on an outer surface of the cylindrical tool body at a first location, and comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates;
and
a second roller disposed on the outer surface of the cylindrical tool body at a second location, and comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body.
2. The apparatus of claim 1, further comprising:
a first cavity within the cylindrical tool body, wherein the first roller is partially disposed within the first cavity; and
a second cavity within the cylindrical tool body, wherein the second roller is partially disposed within the second cavity.
3. The apparatus of claim 1, wherein at least one of the first roller and the second roller comprises an elongated structure longitudinally parallel to the cylindrical tool body.
4. The apparatus of claim 1, wherein:
the cylindrical tool body defines an internal bore; and
the apparatus further comprises a feedthrough positioned within the internal bore.

5. The apparatus of claim 4, wherein the feedthrough is arranged coaxially with the cylindrical tool body.
6. The apparatus of claim 1, wherein the first and second rollers correspond to a 9/8 inch borehole.
7. The apparatus of claim 1, wherein the cylindrical tool body is non-magnetic.
8. The apparatus of claim 1, further comprising a third roller disposed on an outer surface of the cylindrical tool body at a third location, wherein the third location is offset laterally and circumferentially from the first location and the second location on the cylindrical tool body.
9. A method for reducing stick-slip in drilling operations, comprising:
 - coupling a downhole tool to a drill string, wherein the downhole tool comprises
 - a cylindrical tool body;
 - a first roller disposed on an outer surface of the cylindrical tool body at a first location, and comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates; and
 - a second roller disposed on the outer surface of the cylindrical tool body at a second location, and comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body; and
 - positioning the downhole tool within a borehole.

10. The method of claim 9, wherein the downhole tool further comprises:
a first cavity within the cylindrical tool body, wherein the first roller is partially disposed within the first cavity; and
a second cavity within the cylindrical tool body, wherein the second roller is partially disposed within the second cavity.
11. The method of claim 9, wherein at least one of the first roller and the second roller comprises an elongated structure longitudinally parallel to the cylindrical tool body.
12. The method of claim 9, wherein:
the cylindrical tool body defines an internal bore; and
the downhole tool further comprises a feedthrough positioned within the internal bore.
13. The method of claim 12, wherein the feedthrough is arranged coaxially with the cylindrical tool body.
14. The method of claim 9, wherein the first and second rollers correspond to a 9 7/8 inch borehole.
15. The method of claim 9, wherein the cylindrical tool body is non-magnetic.

16. The method of claim 9, wherein the downhole tool further comprises a third roller disposed on an outer surface of the cylindrical tool body at a third location, wherein the third location is offset laterally and circumferentially from the first location and the second location on the cylindrical tool body.

17. A method for manufacturing a downhole tool for reducing stick-slip in drilling operations, comprising:

positioning a first roller on an outer surface of a cylindrical tool body at a first location, the first roller comprising a first longitudinal axis parallel to a longitudinal axis of the cylindrical tool body and about which the first roller rotates; and

positioning a second roller on the outer surface of the cylindrical tool body at a second location, the second roller comprising a second longitudinal axis parallel to the longitudinal axis of the cylindrical tool body and about which the second roller rotates, wherein the second location is offset laterally and circumferentially from the first location on the cylindrical tool body.

18. The method of claim 17, wherein the cylindrical tool body comprises:

a first cavity at the first location; and
a second cavity at the second location.

19. The method of claim 18, wherein:

positioning the first roller at a first location comprises disposing the first roller within the first cavity; and

positioning the second roller at the second location comprises disposing the second roller within the second cavity.

20. The method of claim 17, wherein:
- the cylindrical tool body defines an internal bore; and
- the method further comprises positioning a feedthrough within the internal bore.