

## AN IMPROVED SUB ASSEMBLY

### FIELD OF THE INVENTION

- 5     The invention relates to drill strings, and in particular assemblies to limit or prevent abrasion and wear of said drill string.

### BACKGROUND

- 10    In the oil and gas industry, exploration and extraction processes often require deep wells to be drilled with a long drill string rotating in a long hole. The interaction between the drill string and the well wall introduces a heavy abrasive load, which further develops a very high torque on the drill string and a very large friction force at the contact points between the drill string and the wall. The increase in the torque leads to greater energy  
15    consumption, while the friction may cause wear and damage to the drill string as well as the steel casing used to line sections of the well. Both of the above mentioned issues lead to economic loss create a competitive disadvantage for the drilling service providers. In addition, as drill strings get longer and heavier with addition of more drilling pipes, flexibility increase with more risk of lateral deflection from its expected  
20    axis. The deflection may induce wobbling of the drill bit, and further reduce the drilling rate and increase severe deviation of the hole.

The issue is well known and great effort has been made to overcome drill string friction and deflection problems. One solution involves a rotating collar for the well operations

to prevent friction against a well casing using ball bearing to allow the collar rotating freely relative to the drill string. Another solution involves a drill string bushing tool which is clamped onto the drill string. The bushing tool includes a rigid tubular reinforcing metallic inner sleeve having rubber-like material molded on both the inner and the outer sides of the sleeve. Multiple drill string bushing tools can be disposed on a rotary drill string and allow relative rotation with respect to it to avoid the drill string deflection.

Another system involves using a friction reducing component mounted as a sub in the drill string having a double-sleeve mounted on a mandrel via bearings. The inner sleeve is secured on the mandrel, while the outer sleeve is mounted onto the inner sleeve by way of bushings that allows it rotate freely. As the sleeve is rotatable on the mandrel and non-rotating (stationary) relative to the well wall, this type of sub is classified as “non-rotating” subs.

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However, the above mentioned methods have limited industrial deployment due to issues on cost, complexity and operation. A friction-reducing component with features of simple construction for easy manufacturing, operating and maintaining as well as reasonable low cost is still highly demanded.

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## SUMMARY OF INVENTION

In a first aspect the invention provides a sub assembly for coupling to a drill string, the assembly comprising; a mandrel; a sleeve arranged to be co-axially positioned about

said mandrel; a first stop arranged to prevent axial movement of the sleeve along the mandrel in a first direction; a second stop arranged to prevent axial movement of the sleeve in a second direction; wherein said second stop is releasably engageable from the mandrel.

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The component for reducing friction on a sub is adapted as a part of it. The component is disclosed comprising: a tubular mandrel having first and second ends for connection to adjacent components of the drill string; a sleeve mounted on the mandrel with a first stop casted on the mandrel and a second removable stop attached on the mandrel to  
10 restrain its axial movement relative to the mandrel. The second removable stop can be detached to allow the sleeve to be removed through the second end of the mandrel.

Accordingly, by providing a sub in line with the mandrel, the mandrel itself doesn't require specific modification. The stops then act to trap or enclose the sleeve onto the  
15 sub, with the sleeve remaining secure relative to the mandrel. Replacement is effected through removing the releasable stop and sliding the old sleeve off the sub, allowing ready replacement.

The ready replacement, without modification of the mandrel may allow for special materials for the sub assembly according to the present invention.

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#### BRIEF DESCRIPTION OF DRAWINGS

It will be convenient to further describe the present invention with respect to the accompanying drawings that illustrate possible arrangements of the invention. Other

arrangements of the invention are possible and consequently, the particularity of the accompanying drawings is not to be understood as superseding the generality of the preceding description of the invention.

- 5     Figure 1 is an elevation view of a sub according to one embodiment of the present invention;

Figure 2 is a cross-sectional view of a sub according to a further embodiment of the present invention;

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Figures 3A to 3C are isometric views of a removable stop according to a further embodiment of the present invention;

- Figures 4A to 4C are isometric views of a locking ring according to a further  
15     embodiment of the present invention;

Figures 5A to 5C are various views of fixed pins according to a further embodiment of the present invention.

20     DETAILED DESCRIPTION

The invention describes a friction-reducing sub (sub) with relatively few components.

The sub 5 comprises a tubular mandrel 10 and a sleeve 35 mounted and restrained on the mandrel 10 with a special lubricating material (low coefficient of friction Chromium

alloy) coated on contacting surfaces of the mandrel 10 to allow it to rotate about the sleeve 35 with less friction and wear. The mandrel 10 has a first 25 and a second 30 threaded ends for connection to adjacent drill string components. A sleeve 35 is restrained by a first casted non-removable stop 15 and a second quick-lock stop 20 on the mandrel 10 against axial movement relative to the mandrel 10. The sleeve 35 remains stationary relative to the well wall during the drilling process. The second quick-lock stop 20 is removable from the mandrel 10 to permit the sleeve 35 to be removed over the second end 30 of the mandrel. The bottom of the second stop 20 or the upper end of the sleeve that contact each other may be scalloped to permit fluid flow to provide necessary lubrication. This sub 5 is placed in as a part of a sub string to reduce torque, lower the friction between the drill string and the well wall, and eliminate casing wear as well as the sub tool joint wear.

In conventional non-rotating subs, bearings are applied between the sleeve and mandrel to reduce friction. According to this invention, the relatively simple construction of the sub has an advantage over conventional subs on manufacturing and maintenance by giving up bearings. The fabrication cost is less expensive, and the maintenance is much easier by removing the second quick-lock stop to disassemble the sleeve through the second end of the mandrel. Compared to conventional subs, the present invention uses fewer parts yielding productivity gains through easier installation and assembly whilst maintaining a robust design.

According to this embodiment, the body of the said non-rotating sub is in the form of a tubular straight one- piece mandrel with industrial standard threads in both ends 25, 30

for easy connection into associated drill string as a part in it. The material used for manufacturing the mandrel may include steel 4145H.

According to this embodiment, the first stop 15 for retaining the sleeve is in the form of  
5 a one-piece stop bump integrated on the mandrel 10 machined from a single piece of metal. In this case, the first stop is located on the sub, downstream from the sleeve. However, the first stop may alternatively be located upstream of the sleeve, whilst still being on the sub. The first stop may alternatively be a removable collar attached to the mandrel. The second stop 20 is in the form of a removable collar machined with a single  
10 piece of metal. Figures 2 and 3 show an alternative embodiment where the collar may be fixed on the mandrel with forms of screw thread or releasable connectors such as bolts, clamps, and pins 40 (such as resiliently retractable or sprung pins/dogs) extending radially from the mandrel 10 to engage and retain the collar 65. The collar may define vertical slots 85 there through to allow the dogs 40 to slide in.

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The collar 65 also defines lateral slots 80 in communication with the vertical grooves or slots 85 so that the collar 35 may be rotated to be retained by the dogs. The vertical slots 80 are plugged with a retaining ring 50 comprising a ring portion 55 arranged to sit on the collar 65 as tabs 60 slide into engagement with the vertical grooves 85. This  
20 embodiment of the invention is easy to install without any tool, and easy to remove and replace the sleeve using only common tools such as scissors. This component may be serviced without requiring special skills and sophisticated equipment.

In this embodiment, the sleeve (such as the sleeve 35 shown in Figure 1) is a cylindrical and tubular shape. Blades may be defined on its outer surface to permit drilling fluid flowing through. The material used for manufacturing the sleeve may be steel 4140H. The material for blades may be polymer, metal and a special lubricating material (low  
5 coefficient of friction Chromium alloy) welded to the sleeve. The one-piece robust design of the sleeve allows for high side loading and long working hours rotating in the well.

The sub is similar to the one described in Figure 1 except the locking mechanism of the  
10 second stop. There are T-shape channels 75 or slots defined on the inner surface of the quick-lock retaining collar 65. The quick-lock retaining collar 65 is restrained against axial movement relative to the mandrel 10 using fixed pins 40 which extend radially from the mandrel to engage and retain the quick-lock retaining collar 65. The fixed pins 40 may be inserted in the defined slots in the mandrel with or without tightening by  
15 threads.

It will be appreciated that the fixed pins may be held in place by a number of different means for temporary, or releasable, engagement with the mandrel. The fixed pins are an alternative arrangement to the resiliently retractable pins/dogs.

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The fixed pins are guided into corresponding slots defined on the inner surface of the quick-lock retaining collar. The fixed pins are placed in retaining position by slightly rotating the quick-lock retaining collar. A stop ring 50 with stop tabs 60 is inserted into the vertical slots 85 in the internal surface of the quick-lock retaining collar 65 along the

mandrel axis. The stop tabs 60 as well as the slots 85 in the internal surface of the quick-lock retaining collar will lock the stop ring from being accidentally removed by sudden axial movement of mandrel. The sleeve is free to rotate relative to the mandrel and remains stationary relative to the well wall. Thus, this sub is a “non-rotating” type.

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To dismount or remove the sleeve, the stop ring 50 is dismounted through the second end 30 of the mandrel. Then, the quick-lock retaining collar 65 may be removed through the second end of the mandrel by slightly rotating to place the fixed pins in the guide channels or slots. Finally, the sleeve is removed from the second end of the mandrel.

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The friction between the sleeve and well wall forces the sleeve’s upper end to contact with the lower end of the second stop (quick-lock retaining collar). The well fluid or drilling mud trapped in the sleeve may provide lubrication to reduce the friction between the sleeve and the mandrel, as well as the sleeve end and the end of quick-lock retaining collar. A flow path may be defined between the second stop and the upper sleeve end to permit the fluid entering the gap between the sleeve end and the end of quick-lock retaining collar. A scalloped shape of the fluid path may be advantageous. Alternatively, the scalloped-shape fluid path may be replaced by the existence of the fixed pin channels or slots on the inner surface of the quick-lock retaining collar 65.

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Figures 4A to 4C are detailed views of an alternative stop ring of quick-lock retaining collar as compared to that of Figure 2. Tabs 100 of the stop ring 90 are split into a large body 105 and a thin component 110 with teeth 120 attached facing corresponding teeth on the surface of the fixed pin channels or slots. The teeth may be manufactured in a

variety of ways such as abrading or milling the surface. Alternatively, a special insert may be adhered to the surface having the teeth as a profile on the insert. The thin component 110 of the tabs 100 may be detached by cutting a weakened portion 115.

Access to the weakened portion 115 may be provided through the gap 116 in the collar proximate to each of the axial grooves, to allow a common separating tool like scissors to dismount or remove the stop ring 90, then the quick-lock retaining collar 65, then the sleeve. The stop ring 90 is formed from a single piece of metal.

Figures 5A to 5C show alternative arrangements of the pins. The pins 125, 130, 135 may be in a cylinder shape with or without the end that is to be embedded in the mandrel stepped and threaded. The respective holes in the mandrel which accommodating the fixed pins may be threaded to provide stable installation of the fixed pins. The end of the fixed pin embedded in the mandrel is possible to be larger, equal or smaller in diameter compared to the other end extruded into the quick- lock retaining collar. As shown in Figure 5C it may be possible that the end of the fixed pin embedded in the mandrel is in a cylinder shape 145, while the other end extruded into the quick- lock retaining collar is in a square pillar shape 140. The same diameter and shape may be used for both ends for easy manufacturing and installation. The fixed pins are formed from a single piece of metal.

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The fixed pins may be in a one- piece design extending radially from the mandrel to engage and retain the retaining collar. The extruding end of the fixed pin may be a cylinder shape, but it is not limited to other shapes such as square or rectangle pillar shapes. These one-piece fixed pins make it easy for installation.

The fixed pins are arranged to engage and position in the lateral channels or slots on the inner surface of the quick-lock retaining collar. The rotation of the sub leads to a friction force between the sleeve and the quick-lock retaining collar that tends to force the fixed

5 pins to the blind ends of the lateral channels or slots. The opening of these channels or slots will be fully filled with the stop pins of the stop ring to retain the fixed pin in position to force the sleeve against axial movement relative to the mandrel. Based on present invention, further modifications and improvements may be made by adapting blades on the external surface of the sleeve to assist the drilling mud flowing through.

10 According to this embodiment, no special tool is required for installation, and only a simple separating tool is used for dismounting the sleeve.

## CLAIMS

1. A sub assembly for coupling to a drill string, the assembly comprising;  
a mandrel;  
5 a sleeve arranged to be co-axially positioned about said mandrel;  
a first stop arranged to prevent axial movement of the sleeve along the mandrel  
in a first direction;  
a second stop arranged to prevent axial movement of the sleeve in a second  
direction;  
10 wherein said second stop includes an annular collar arranged to be co-axially  
positioned about the mandrel, said collar having axially and circumferentially  
directed grooves on an inside face, said grooves engageable with pins projecting  
from said mandrel, such that the second stop is releasably engageable with the  
mandrel.  
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2. The sub assembly of claim 1, wherein the first stop is integral with the mandrel.
3. The sub assembly according to claim 1, wherein said pins are resiliently  
retractable dogs arranged to be biasedly retracted on contacting the collar and  
20 resiliently project on proximity to said grooves.
4. The sub assembly according to claim 1, wherein said pins are fixed and arranged  
to allow sliding of the collar along said axial grooves and permit rotation of the  
collar along said circumferential grooves.

5. The sub assembly according to any one of claims 1 to 4, further including a stop ring arranged to be co-axially positioned about the mandrel, said stop ring having a plurality of axially projecting tabs, and arranged to couple with the collar such that the tabs are arranged to be placed in sliding engagement with the axially directed grooves of said collar, wherein on engagement with said grooves, said tabs are arranged to prevent rotation of said collar so as to fix the collar to said pins and consequently the mandrel.
6. The sub assembly according to claim 5, wherein the tabs are selectively breakable so as to disengage the stop ring from said collar.
7. The sub assembly according to claim 6, wherein said collar includes a gap proximate to the axial grooves and arranged to provide access to break said selectively breakable tabs.
8. The sub assembly according to claim 5 or 6, where said tabs include teeth on a collar engaging face, said teeth arranged to increase frictional resistance.
9. The sub assembly according to any one of claims 5 to 7, wherein the collar includes teeth on a stop ring engaging face said teeth arranged to increase frictional resistance.