A torque anchor for anchoring well equipment in a well conduit to arrest movement in both longitudinal directions and rotation in a first direction, but not rotation in an opposed second direction. A mandrel connected to the equipment has L-shaped grooves for slideably receiving respective pins from a drag body on the mandrel. A slip retainer on the mandrel houses slips for selectively engaging and disengaging the conduit. An initial pull of the mandrel causes the pins to move the drag body toward the slip retainer driving the slips outward to grip the conduit, and rotation of the mandrel in the first direction sets the anchor to arrest movement. Further pulling maintains the set position. The anchor is unset by releasing pull, rotating the mandrel in the second direction, and pushing the mandrel to disengage the slips. Alternate unsetting requires increased pull beyond the shear resistance of the slip retainer.
QUARTER TURN TENSION TORQUE ANCHOR

FIELD OF THE INVENTION

[0001] The present invention relates to tools for oil and gas wells generally, including wells accessing heavy crude, and in particular relates to a torque anchor for anchoring well equipment, such as a progressive cavity pump, and related tubing string in a well conduit from rotation in a given direction and from movement in both linear directions along the well conduit.

BACKGROUND OF THE INVENTION

[0002] Known torque anchors, also referred to as anchor catchers, use either a combination of right and left hand threads, or are limited to one thread orientation. Examples of such torque anchors are shown in U.S. Pat. No. 3,077,933 to Bigelow and in Canadian patent no. 933,089 to Conrad. Disadvantages of such torque anchors include the expense of manufacturing the threaded portions, and the stop pins are vulnerable to breakage during use.

[0003] Another type of torque anchor shown in U.S. Pat. No. 5,771,969 and corresponding Canadian patent no. 2,160,647 to Garay avoids the aforementioned threads and instead uses a helical bearing to transform rotational movement into linear movement for setting and unsetting the torque anchor. The helical bearing also accommodates shear pins for secondary unsetting if required. The use of one component, namely the helical bearing, to perform several functions has the advantage over the previous prior art of being less expensive to manufacture and less susceptible to breakage.

[0004] However, there is a need for a torque anchor that further improves on these prior designs. In particular, there is a need for a torque anchor that avoids the prior art threads and helical bearings that require multiple full (i.e. 360 degree) rotations of the torque anchor's mandrel to either set or unseat the torque anchor. The torque anchor should not need to translate rotational movement into linear movement to engage the anchor slips with the well conduit, but rather should directly transfer a short longitudinal movement of the mandrel to extend the slips into gripping engagement with the well conduit. The torque anchor should require only a limited rotation, such as a quarter turn, of the mandrel in a first direction to set the torque anchor, and to help maintain the anchor in the set position by merely pulling tension on the conduit via the tubing string. One or more tracks in the mandrel, each formed by a groove having joined longitudinal and transverse arms, should guide a corresponding drive pin to achieve the desired longitudinal and rotational movements.

The groove's arms should be relatively short to reduce both manufacturing costs and the risk of debris entering the groove to interleave with proper operation. The torque anchor should have a secondary unsetting capability where release is achieved by merely pulling the mandrel at a predetermined force to sever certain fasteners mounted to the mandrel, rather than shearing the drive pins in the grooves.

SUMMARY OF THE PRESENT INVENTION

[0005] According to the present invention, there is provided a torque anchor for anchoring well equipment in a well conduit to arrest movement in both longitudinal directions and rotation in a first direction comprising:

[0006] a mandrel connected to said well equipment;
[0007] a cone element mounted to said mandrel and having a first conical surface;
[0008] a drag body mounted on said mandrel, housing a drag means for contacting said well conduit, and having a second conical surface;
[0009] a slip retainer mounted on said mandrel housing a plurality of slips, each of said slips having an inner surface, and an opposed outer surface for gripping said well conduit, and biasing means for urging said slip inwardly toward said mandrel and away from said well conduit;
[0010] at least one pin connected to said drag body and a portion of said pin protruding toward said mandrel; and,
[0011] said mandrel having at least one L-shaped groove for slidably receiving said protruding portion of said pin;
[0012] wherein an initial pulling of said mandrel causes said pin, and in turn said drag body, to move toward said cone element so that said second conical surface of said drag body contacts said inner surface of said slips and urges said inner surface to contact said first conical surface of said cone element to drive said slips outward so that said outer surfaces of said slips grip said well conduit, and a further rotation of said mandrel in said first direction sets said torque anchor.

[0013] In another aspect the invention provides a method of anchoring well equipment in a well conduit to arrest movement in both longitudinal directions and rotation in a first direction, and to allow rotation in an opposite second direction, using a torque anchor having:

[0014] a mandrel connected to said well equipment;
[0015] a cone element mounted to said mandrel with fasteners;
[0016] a drag body mounted on said mandrel, housing a drag means for contacting said well conduit;
[0017] a slip retainer mounted on said mandrel housing a plurality of slips for moving into and out of gripping engagement with said well conduit;
[0018] at least one pin operatively engaging said drag body to said mandrel; and,
[0019] said mandrel having at least one groove with a first longitudinal arm and a second circumferential arm, for slidably receiving said pin;

[0020] exerting an initial pull on said mandrel to move said pin along said first leg of said groove to extend said slips to grip said well conduit; and,
[0021] then rotating said mandrel in said first direction to move said pin along said second leg of said groove to set said torque anchor.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

[0022] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

[0023] FIG. 1 is a side view of a torque anchor according to a preferred embodiment of the present invention, shown in a run (unset) orientation;
[0024] FIG. 2 is a perspective view, in isolation, of a mandrel of the torque anchor of FIG. 1;
[0025] FIG. 3 shows the torque anchor of FIG. 1 in a run position within a segment of well conduit shown in transparent view;
[0026] FIG. 3a is a cross-sectional view of the torque anchor and well conduit along line 3a-3a of FIG. 3;
FIG. 4 shows the torque anchor and well conduit of FIG. 3 with a partially transparent view of a drag body housing:

FIG. 4a is a close up view of the circled area 4a of FIG. 4.

FIG. 5 is a longitudinal section through the torque anchor and well conduit of FIG. 3, generally along the line 5-5.

FIG. 6 shows a set position of the torque anchor of FIG. 3 in the conduit:

FIG. 6a is a cross-sectional view of the torque anchor and well conduit along line 6a-6a of FIG. 6; and

FIG. 7 is a longitudinal section through the torque anchor and well conduit of FIG. 6, generally along the line 7-7.

DESCRIPTION OF PREFERRED EMBODIMENTS

Referring first to FIGS. 1 to 5, a preferred embodiment of a torque anchor, generally indicated by reference numeral 10, is shown inserted within a well conduit 12, such as a wellbore casing. The torque anchor is shown in an unset, or “run-in”, orientation in which it can be run inside the well conduit on a tubing string, along with other well equipment 14, such as a safety sub, attached above and below. In particular, the well equipment is attached to a cylindrical mandrel 20 having attachment means, such as an inner threaded lower end 22 and an outer threaded upper end 24. In this embodiment, the torque anchor is run down the well conduit on the tubing string in the direction indicated by arrow 16. It is noted, however, that terms such as “up”, “down”, “forward”, “backward” and the like used to identify certain features of the torque anchor when placed in a well conduit is not intended to limit the torque anchor’s use or orientation. Further, when describing the invention, all terms not defined herein have their common art-recognized meaning.

The torque anchor has a tubular drag body 40 mounted over the mandrel 20 to house a drag means in the form of multiple drag blocks 42 for spacing the torque anchor away from the inner wall 13 of the conduit 12. In the preferred embodiment four drag blocks 42 are generally evenly spaced circumferentially about the torque anchor. Each drag block 42 has a drag spring 44 to urge the outer surface 46 of the drag block against the conduit’s inner wall 13. Upper and lower drag retaining rings 48, 50 keep the drag blocks 42 removably mounted within the drag body 40. At least one lower cap screw 52 attaches the lower retaining ring 50 to the drag body 40. For illustrative purposes, FIG. 3a shows the use of three circumferentially staggered cap screws 52. In addition to keeping the torque anchor spaced from the conduit, the contact of the drag block surface 46 with the conduit’s inner wall 13 can induce friction that urges the drag body 40 to remain stationary while the mandrel 20 moves within.

A tubular slip retainer 60, or slip cage, mounted on the mandrel 20 adjacent the drag body 40 houses a plurality of radially movable slips 62. In the drawings three slips 62 are shown generally evenly spaced about the drag body. Each slip has an outer surface 63 with teeth for gripping the conduit wall 13 upon contact, and an inner surface with opposed outwardly inclined edges 64. A fastener in the form of a socket head cap screw 65 is fastened to the drag body 40 and is located within each of a plurality of elongate slots 66 spaced circumferentially about the slip retainer, preferably between each slip. The cap screw 65 is adapted to contact the upper and lower shoulders 68a, 68b at the ends of the slot, which form stop means to prevent the slip retainer 60, and the drag body 40, from moving off the mandrel 20.

A cone element 70 at an upper end of the slip retainer is mounted to the mandrel 20 by a plurality of circumferentially spaced fasteners in the form of set screws 72. These set screws also act as shear pins to release the torque anchor from a set position upon exertion of sufficient tension on the well equipment, as will be discussed later. The edge of the cone 70 opposite the set screws 72 forms a first conical surface 74 whose inclined surface wedges under the slips 62 when the torque anchor is moved into a set position. Likewise, an upper edge of the drag body 40 forms a second conical surface 54 whose inclined surface concurrently wedges under the slips 62 when the torque anchor is moved into a set position. However, the first and second conical surfaces 74, 54 should not actively contact the slips in the unset position, as shown in FIG. 5. A biaser in the form of a slip spring 76 urges each slip 62 radially inwardly into the slip retainer and away from the well conduit 12 in the unset position (FIG. 5).

An important aspect of this torque anchor is the configuration of the at least one groove 80 formed in the mandrel’s outer cylindrical surface 26, best seen in FIG. 2. The L-shaped groove has a first or upper arm 82 extending longitudinally with a shoulder 83 at its upper end forming a stop and an elbow 81 at its lower end. A second or lower arm 84 extends circumferentially from the elbow 81 at a generally right angle to the upper arm 82. A terminal end 86 of the lower arm forms another stop and has opposed indents 86a, 86b extending longitudinally upwardly and downwardly therefrom. The groove 80 is dimensioned (width, depth) to slidably accommodate a portion of a drive pin 88 extending therein threaded through a hole 56 in an lower part of the drag body 40 (FIG. 5). The lower retaining ring 50 keeps the drive pin 88 within the drag body 40 and engaged within the groove 80. In the FIG. 3a embodiment three sets of grooves 80 and drive pins 88 are shown generally evenly spaced about the mandrel.

The operation of the torque anchor may now be described with reference to all figures, including FIGS. 6 to 7 showing the torque anchor in the set position in the well conduit 12. There are generally two steps for moving the mandrel 20 in a “setting direction” to the set position, and a third step to help fix or maintain that set position. The first step is to initially push the mandrel upwardly by lifting the tubing string 14 in the direction of arrow 17, so that each drive pin 88 travels downwardly along the first arm 82 of the respective groove to the elbow 81 (FIG. 2). In this embodiment that travel is relatively short, approximately 2.5 mm (about 1.0 inch). The pull on the mandrel forces the drive pins 88 to push the drag body’s second conical surface 54 toward the first conical surface 74 of the cone element 70. As these two components converge, the conical surfaces contact the inner edges 64 of each slip 62 to drive the slips outwards, so that the slip’s outer surface 63 contacts and bites into the well’s inner wall 13. As a result, the mandrel 20 and the attached well equipment are fixed such that they can not move longitually in the well either up or down. At this point the second step is to turn the tubing string to the right (i.e. clockwise when looking down the tubing string in the direction of arrow 16, in this embodiment) approximately “a quarter turn” (i.e. about 90 degrees) so that each drive pin 88 travels along the lower arm 84 from the elbow 81 to the stop 86. At this point the mandrel and tubing string should be rotationally fixed in
this first, or clockwise, setting direction. And finally the third step is to maintain the torque anchor in this set orientation by continuing to pull tension on the tubing string straight up, which should also engage the drive pin 88 with the lower indent 86b which "stores" the pin upon entry to aid in maintaining the set position. The drill string should be kept in tension as long as the set position is desired.

[0039] The torque anchor is released, or unset, by reversing the above described setting procedure. The first unsetting step requires release of tension by moving the tubing string, and hence the mandrel 20, down somewhat, which should move the drive pins 88 out of the corresponding lower indent 86b to the upper indents 86a which temporarily "store" the pins on exit. The second step requires rotating the tubing string and mandrel in a second direction opposite to the setting rotation, namely turning to the left (i.e. counter-clockwise when looking down the tubing string in the direction of arrow 16, in this embodiment) approximately "a quarter turn" so that each drive pin 88 travels from the upper indents 86a along the lower arm 84 to the elbow 81. Finally, in a third step, the mandrel should be moved further down relative to the drag body so that the drive pin 88 travels up the upper arm 82 from the elbow 81 toward the stop 83. After the pin reaches this stop, continuing this mandrel movement causes the drag body 40 to move downwards, and thereby the second conical surface 54 to move away from the inner edge 64 of each slip 62. The springs 76 urge the respective slips 62 inward away from the well’s inner wall 13, thus releasing the torque anchor for movement longitudinally (both up and down the well) and rotationally (in the unsetting direction). This allows the torque anchor to be moved to a different position in the well conduit 12 and be set again, or to lift the torque anchor and remove it from the well conduit.

[0040] An alternate method of unsetting the torque anchor is to pull tension on the tubing string to exert sufficient upward force on the mandrel 20 to shear the set screws 72 by exceeding their maximum shear resistance. Once the set screws are sheared, the cone element 80 becomes detached from the mandrel 20 and is free to move away, namely upward, from the slips 62, allowing the springs 76 to retract the slips away from the inner surface 13 of the conduit. The torque anchor is therefore freed for removal from the well conduit 12. The maximum shear resistance may be "adjusted" by either changing the set screws 72 to ones with a different shear value, or by altering the number of set screws inserted into the cone element 80. For instance, in one version of the torque anchor, twelve brass screws 72 can be employed each with about 5000 pounds (2273 kg) resistance, and their maximum shear resistance does not exceed that of the drive pins 88 to avoid damaging the pins during such secondary release of the torque anchor.

[0041] Some of the many advantages of the present invention may now be better appreciated. The torque anchor 10 is designed to anchor the tubing string from movement longitudinally along the well (in both directions, up and down the well) and from rotation (in the setting direction). The anchoring is achieved by simple setting and release procedures with relatively little movement of the tubing string. In this instance, setting is achieved by a small pull of the mandrel (via the tubing string) that is adequate for the drive pin 88 to travel the short distance along the longitudinal arm 82 to reach the elbow 81, and then by a small "quarter" turn of the mandrel that is adequate for the drive pin 88 to travel the short distance along the circumferential arm 82 to reach the toe 85, and finally by further pulling to engage the drive pin 88 with the lower indent 86b. The torque anchor 10 avoids the more labourious and time consuming multiple full rotations of the mandrel that are currently required to set a torque anchor. The relatively short L-shaped groove 80, in comparison to the multiple twists of the long threads or helical groove of other mandrels, reduces the risk of foreign objects obstructing the drive pin’s travel path, and thus should improve the torque anchor function, reliability and wear. Also, since this anchoring is achieved by placing the tubing string in tension, there is an added benefit of ensuring that the tubing follows the rod string as closely as possible, which helps minimize rod wear.

[0042] Some further benefits are set out below.

[0043] The configuration of the torque anchor, including the arrangement of the set screws with a given shear resistance below that of the drive pins 88, provides a relatively fast and easy secondary unsetting of the torque anchor in case of an emergency or should a problem be encountered with the primary means of setting and unsetting via the L-shaped groove 80.

[0044] Referring to FIG. 6b, the slips 62 are configured not only to center the torque anchor within the well conduit 12, but radially protrude sufficiently from the slip retainer 60 to provide large by-pass spaces 78 between the torque anchor and the conduit, creating high flow areas for fluids (e.g. gas) and solids (e.g. sand) to pass by the torque anchor, and allowing coil tubing to more easily extend past the torque anchor, than other torque anchors. In the FIG. 6b version, for instance, by-pass spaces 78 with 1.0 inch (25.4 mm) radial clearance are created between the 4.5 inch (114.3 mm) OD of the slip retainer 60 and the 6.5 inch (165.1 mm) ID of the well conduit 12.

[0045] The configuration of the torque anchor 10 permits capillary cable to be carried downhole via the large by-pass spaces 78 created by this novel torque anchor design. In particular, the fact that the torque anchor 10 is set and unset by longitudinal motion and a limited, quarter turn, permits its use with the capillary cable since the anchor stays relatively straight during use, thus avoiding wrapping of the cable around the anchor. In contrast, prior art anchors that require multiple full (360 degree) rotations—between two to seven full rotations for setting and unsetting—cause an undesirable wrapping of the cable around the anchor, which damages the cable. Alternately, the cables must be pre-wrapped when inserted with these prior art anchors, so that they unwrap as the anchor is twisted during setting, which is tedious and undesirable.

[0046] The drag blocks 42 have been hardened, over prior art drag blocks, for longer life. The slips 62 are made of solid high strength metal for superior durability and grip on the well conduit wall 13, and Inconel™ type springs 76 are employed for improved resistance to H₂S and CO₂. Further, the surface of the mandrel 20 is optionally coated with Teflon® for improved resistance to H₂S and CO₂, and to help maintain mandrel strength.

[0047] The above description is intended in an illustrative rather than a restrictive sense, and variations to the specific configurations described may be apparent to skilled persons in adapting the present invention to other specific applications. Such variations are intended to form part of the present invention so far as they are within the spirit and scope of the claims below.
We claim:

1. A torque anchor for anchoring well equipment in a well conduit to arrest movement in both longitudinal directions and rotation in a first direction comprising:
   - a mandrel connected to said well equipment;
   - a cone element mounted to said mandrel and having a first conical surface;
   - a drag body mounted on said mandrel, housing a drag means for contacting said well conduit, and having a second conical surface;
   - a slip retainer mounted on said mandrel housing a plurality of slips, each of said slips having an inner surface, and an opposed outer surface for gripping said well conduit, and biasing means for urging said slip inwardly toward said mandrel and away from said well conduit;
   - at least one pin connected to said drag body and a portion of said pin protruding toward said mandrel; and,
   - said mandrel having at least one L-shaped groove for slidably receiving said protruding portion of said pin;

   wherein an initial pulling of said mandrel causes said pin, and in turn said drag body, to move toward said cone element so that said second conical surface of said drag body contacts said inner surface of said slips and urges said inner surface to contact said first conical surface of said cone element to drive said slips outward so that said outer surfaces of said slips grip said well conduit, and a further rotation of said mandrel in said first direction sets said torque anchor.

2. The torque anchor of claim 1 wherein said L-shaped groove comprises:
   - a first arm extending longitudinally on said mandrel having a shoulder at one end forming a first stop and an elbow at an opposed end; and,
   - a second arm having one end extending circumferentially from said elbow and an opposed end forming a second stop;

   wherein said pin travels to said second stop when setting said torque anchor and travels to said first stop when unsetting said torque anchor.

3. The torque anchor of claim 2 further comprising an indent at said second stop of said second arm wherein a further pulling of said mandrel engages said pin with said indent to help maintain said torque anchor in a set position.

4. The torque anchor of claim 2 wherein said first arm is located generally perpendicularly to said second arm.

5. The torque anchor of claim 2 wherein said second arm is configured so that about one quarter turn of said mandrel is sufficient to bring said pin from said elbow to said second stop.

6. The torque anchor of claim 2 wherein said first arm provides about 2.5 mm of travel therein for said pin.

7. The torque anchor of claim 1 wherein a plurality of fasteners fixing said cone element to said mandrel are adapted to shear off to provide a secondary release means when said mandrel is pulled in tension in excess of the failure shear resistance of said fasteners.

8. The torque anchor of claim 1 wherein said inner surface of said each slip forms opposed inclined edges for contacting said first and second conical surfaces to form a wedging action for urging said slip away from said mandrel.

9. The torque anchor of claim 1 wherein said slips are generally equidistantly spaced about said slip retainer to centre the torque anchor within the well conduit, and said slips radially protrude from said slip retainer to create large bypass spaces therebetween for well fluids and equipment.

10. A method of anchoring well equipment in a well conduit to arrest movement in both longitudinal directions and rotation in a first direction, and to allow rotation in an opposite second direction, using a torque anchor having:
    - a mandrel connected to said well equipment;
    - a cone element mounted to said mandrel with fasteners;
    - a drag body mounted on said mandrel, housing a drag means for contacting said well conduit;
    - a slip retainer mounted on said mandrel housing a plurality of slips for moving into and out of gripping engagement with said well conduit;
    - at least one pin operatively engaging said drag body to said mandrel; and,
    - said mandrel having at least one groove with a first longitudinal arm and a second circumferential arm, for slidably receiving said pin;

    wherein said method comprises:
    - exerting an initial pull on said mandrel to move said pin along said first leg of said groove to extend said slips to grip said well conduit; and,
    - then rotating said mandrel in said first direction to move said pin along said second leg of said groove to set said torque anchor.

11. The method of claim 10 comprising exerting a further pull on said mandrel, after said rotation, to maintain said torque anchor in said set position.

12. The method of claim 11 wherein unsetting of said torque anchor comprises:
    - releasing said pull on said mandrel;
    - rotating said mandrel in said second direction to move said pin along said second leg to said first leg; and,
    - moving the mandrel so that said pin travels along said first leg, thereby releasing said slips from said well conduit to allow said torque anchor to slide along said well conduit.

13. The method of claim 11 wherein a secondary unsetting of said torque anchor comprises increasing said further pull on said mandrel until the failure shear resistance of said fasteners is exceeded.

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