DOWNHOLE CATCHER FOR AN ACTUATING BALL AND METHOD

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ABSTRACT

A ball catching device has been invented that catches an actuator ball used in a wellbore to actuate a downhole tool. The device catches the ball downhole as it begins to flow back with fluids toward surface. The device is configured such that when a ball flows back with wellbore fluids, the ball can flow through the device and if the ball reverses direction, as by falling back due to decreased or stopped production backflow, then the device will catch the ball and keep it from falling back past the device into the well.
FIG. 5
DOWNHOLE CATCHER FOR AN ACTUATING BALL AND METHOD

FIELD

[0001] The present invention relates to wellbore tools, installations and processes. In particular, a downhole tool for addressing the use of downhole tool actuators, herein referred to as actuating balls.

BACKGROUND

[0002] Some wellbore processes employ actuators to activate downhole tools. For example, in some wellbore stimulation processes, as described in U.S. Pat. No. 7,861,774 and U.S. Pat. No. 7,748,460, both for Packers Plus Energy Services Inc., actuators of various sizes are employed to activate sliding sleeves such as those over frac ports. As described therein, stimulation of vertical and horizontal wells may proceed by dropping actuators to actuate the sliding sleeves. The actuators can be in the shape of balls, plugs, darts, etc., but are commonly referred to as balls.

[0003] In certain cases, it may be necessary to retrieve all balls from the wellbore that were used to actuate downhole tools. For example, after deploying balls, it may be of interest to go in and do some kind of an intervention in the well. For example, an operation could be undertaken to shift previously opened sleeves to closed positions for example to re-frac the well or to shut off water. As another example, it may be of interest to do a production log, which is run typically on coiled tubing or jointed tubing. If the balls remain in the well, one or more of the balls may prevent the strings/tools from achieving total depth. A ball may blank off the operation.

[0004] It has been believed that balls will work their way out of the well by flow back. In particular, after a ball is pumped and used to actuate a downhole tool, the operator may begin to flow the well back. When the well begins to flow back, the balls generally begin to move with the flowing fluids back up the well. The balls typically will move along the base of the horizontal well and to the heel of the well without much problem. However, when the balls reach a vertical section, the lifting forces of the fluid may be inadequate to continue to carry the balls. As such, the balls tend to flow up to a certain point in the well but they may not flow all the way up to surface.

SUMMARY

[0005] In accordance with broad aspects of the present invention, there are provided a catcher for a wellbore actuation ball, a wellbore assembly and a method for wellbore operations.

[0006] For example, in one aspect, there is provided a downhole ball catcher for preventing an actuation ball migrating upwardly through a well from falling back down deeper into the well after passing upwardly through the downhole ball catcher, the downhole ball catcher comprising: a main housing sized to be positioned downhole in the well and including a bottom end, a top end, an inner open area and openings for fluid flow from the bottom end, through the inner open area and out through the top end; and a protrusion connected by a moveable connection to the main housing and positioned in the inner open area in a blocking position to block passage of a ball through the inner open area, the moveable connection being configured to allow movement of the protrusion away from the blocking position in response to a ball pushing upwardly past the protrusion toward the top end and the moveable connection being configured to resist movement of the protrusion away from the blocking position to prevent movement of the ball downwardly past the protrusion toward the bottom end.

[0007] In a further aspect there is provided a wellbore assembly comprising: an actuator ball in the well useful to actuate a downhole tool and moveable to migrate upwardly in the well as driven by back flow of wellbore fluids; and an actuator ball catching device positioned in a lower portion of the well above the actuator ball, the device including a main housing with a fluid flow passage from a bottom end to an upper end and formed to be removable from the well by pulling to surface and the device having a mechanism to allow the passage of an actuator ball moving up through the device, the mechanism preventing the actuator ball from moving down past the device into the well.

[0008] In a further aspect there is provided a method for catching an actuation ball from a wellbore, the method comprising: positioning an actuator ball catching device downhole in a wellbore; back flowing wellbore fluids to push an actuator ball along the wellbore to the actuator ball catching device; catching the actuator ball by allowing the actuator ball to move up through the actuator ball catching device, the actuator ball catching device catching the actuator ball by preventing the actuator ball from falling back down into the well; and retrieving the actuator ball catching device to surface along with the actuator ball caught in the actuator ball catching device.

[0009] It is to be understood that other aspects of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein various embodiments of the invention are shown and described by way of illustration. As will be realized, the invention is capable for other and different embodiments and its several details are capable of modification in various other respects, all without departing from the spirit and scope of the present invention. Accordingly the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Referring to the drawings, several aspects of the present invention are illustrated by way of example, and not by way of limitation, in detail in the figures, wherein:

[0011] FIGS. 1A, 1B and 1C are a series of schematic illustrations of an embodiment of a downhole ball catching device in section in a well and a method for catching an actuation ball. FIG. 1A illustrates the ball catcher in position in a well with a ball approaching the ball catcher from below as driven by flow back. FIG. 1B illustrates the ball moving upwardly through the protrusions of the ball catcher, as driven by flow back, with the protrusions flexing out of the way to permit the movement. FIG. 1C illustrates the ball caught in the ball catcher, the protrusions holding the ball in the ball catcher and ball being unable to move back downhole since the protrusions stop such movement.

[0012] FIGS. 2A, 2B and 2C are a series of schematic illustrations of one embodiment of a downhole ball catcher in quarter section and a method for activating the ball catcher. FIG. 2A shows the ball catcher in a run in position with an activation ball just landed therein. FIG. 2B shows the ball catcher after activation. FIG. 2C shows the ball catcher activated and having operated to catch an actuator ball. FIG. 2D
shows a bottom perspective view of a ball catcher, with a section through the housing oriented with reference to line I-I in FIG. 2C. FIGS. 3A to 3D are a series of schematic illustrations of one embodiment of a downhole ball catcher in section in tubing string in a well and a method for catching a plurality of actuation balls. FIG. 3A illustrates the ball catcher incorporated in a tubing string and in position in a well in an inactive position, where it has not interfered with actuation balls conveyed to drive processes below the ball catcher. FIG. 3B illustrates the ball catcher being activated by an actuation ball. In FIG. 3C, the ball catcher has caught a plurality of actuation balls including the activation ball used to activate it. FIG. 3D shows the tubing string being pulled toward surface with the balls remaining in the ball catcher and also, therefore, being retrieved.

FIGS. 4A, 4B and 4C are a series of schematic illustrations of one embodiment of a downhole ball catcher in quarter section and a method for activating the ball catcher. FIG. 4A shows the ball catcher with balls caught therein. FIG. 4B shows the ball catcher before a bypass is opened. FIG. 4C shows the ball catcher the ball catcher after a bypass is opened.

FIG. 5 is a partial sectional view through another all catcher.

FIGS. 6A and 6B are a series of schematic illustrations of the ball catcher of FIG. 5 in a well and a method for catching a plurality of actuation balls. FIG. 6A illustrates the ball catcher in position in a well in an active position. FIG. 6B shows the ball catcher being pulled toward surface with balls caught in the ball catcher.

DETAILED DESCRIPTION OF VARIOUS EMBODIMENTS

The description that follows, and the embodiments described therein, is provided by way of illustration of an example, or examples, of particular embodiments of the principles of various aspects of the present invention. These examples are provided for the purposes of explanation, and not of limitation, of those principles and of the invention in its various aspects. The drawings are not necessarily to scale and in some instances proportions may have been exaggerated in order more clearly to depict certain features. Throughout the drawings, from time to time, the same number is used to reference similar, but not necessarily identical, parts.

Actuation balls are used in wellbore actuation. As noted above, if an actuator ball remains in the wellbore, wellbore interventions may be impossible or complicated. Flow back, while sometimes successful to remove the balls, cannot be relied upon in all situations. However, if the balls are removed from the well, it may be more readily possible to run tools or strings in to activate well apparatus or to inspect or treat the well. If the balls can be removed, they won’t create restrictions in the well. Thus, the ability to retrieve all the actuation balls is beneficial especially if intervention techniques are to be attempted thereafter.

While the term ball is used, it is to be understood that the term can broadly be used to refer to non-spherical actuators, such as rods, darts, etc., sometimes also referred to as actuator plugs or actuator tools. Also, while a particular device may be deployed, it may break apart downhole and the resultant broken parts may also be problematic. It is intended that all such components including balls, plugs, tools, and broken pieces thereof are encompassed by the term balls.

A ball catching device has been invented that catches an actuator ball used to actuate a downhole tool. The device catches the ball downhole as it begins to flow back with fluids toward surface. The device is configured such that when a ball flows back with wellbore fluids, the ball can flow through the device and if the ball reverses direction, as by falling back due to decreased or stopped production back flow, then the device will catch the ball and keep it from falling back past the device into the well.

With reference to FIGS. 1A to 1C, a ball catcher device includes a main housing 12 with an inner open area 14 and one or more protrusions 16 in the inner open area moveably connected to the main housing 12. The one or more protrusions are configured via their moveable connection 18 to allow a ball 15 to move, arrow A, upwardly therethrough toward surface (FIG. 1B). The one or more protrusions are also configured via their moveable connection 18 to block any reverse movement of that ball downwardly therepast (FIG. 1C).

Protrusion 16 may take various forms. A protrusion may be, for example, a finger, a collet, a flapper, a dog, etc.

Moveable connection 18 may take various forms including any of pivots, flexing members, sliders, etc. For example, as shown, moveable connection 18 may be formed as flexible base portions 24 of the protrusions. The flexible base portions are formed of material such as resilient steel angled in a direction that allows each protrusion to flex between a blocking position and a position allowing upward movement therepast, but resist any movement from the blocking position to a position allowing downward movement therepast. As such, flexible base portions 24 allow a ball to push the protrusions out of the way when the ball is moving upwardly against the protrusions. However, once the ball passes the protrusions, the protrusions flex back into the blocking position and if the ball reverses direction and attempts to move back down in the well, the protrusions cannot flex past the blocking position and the protrusions resist downward movement of the ball therethrough.

Inner open area 14 is sized to accommodate at least one ball 15 to be caught.

Main housing 12 and protrusions 16 may be formed to allow fluid flow therethrough, such as for example, flow from a bottom end 12a of the main housing, past protrusions 16 and out through a top end 12b of the main housing such that fluid flow, arrows F, toward surface is not sealed off. Main housing 12 can take various forms. For example, main housing 12 may be formed as a tubular member for example with inner open area passing through and being open at the bottom and top ends. The main housing can: have solid walls or perforated walls, be shaped in various ways; and/or can include locking structures for locking to a wellbore structure or fishing structures such as an upper gland 20 for accepting engagement of a retrieval tool.

The basket can be open topped, with end 12b having a diameter sized to allow an actuator ball to pass through, since upward further travel of the balls past the basket toward or fully to surface is not a problem.

The ball catcher device may be a separate structure, as shown in FIG. 1, independently positionable in a well 22 or may be installed as part of a tubing string, as shown in later Figures.

As a separate structure, the ball catcher device may be likened to a basket that is sized to be moved through the well to be installable to catch one or more balls and, thereaf-
ter, retrievable to carry any caught balls out of the well. The basket can catch one or more of the balls in the well, but allow fluid to pass therethrough. The basket can be released from surface and moved by pumping or gravity, mechanically run on a string such as tubing (i.e. jointed tubing, coiled tubing, etc.) or wireline (i.e. slickline, brained line, e-line, control line, etc.), or connected to and carried into the well on another wellbore apparatus, such as the tubing string to be actuated. Once in place, it may simply rest unsecured in well 12 (as shown) or it may lock into a structure in the well.

[0029] The protrusions act like a one-way valve for the ball, acting to allow the ball’s movement in one direction, while restricting the ball’s movement in the opposite direction. The device is positioned such that the protrusions restrict the ball from moving downward therepast, but allow the ball to move upward therepast.

[0030] When the well is flowed back, any balls in the well such as ball 15 will start to move uphole toward surface. As a ball approaches the protrusions from below, the protrusions are initially in a blocking position (FIG. 1A) but the protrusions are only active to prevent downward movement of the ball, such that the ball is able to come up through protrusions 16 into inner open area 14 of the basket above the protrusions. As shown in FIG. 1B, the protrusions can move, arrows M, out of the way of a ball passing in a first direction up there-through and, therefore, allow the ball to pass. In this operation, the protrusions move along arrows M in a direction out of the blocking position. One or more of the protrusions of the mechanism may be moved by a ball pushing upward therepast.

[0031] The protrusions resist movement away from the blocking position in a direction opposite to the above-noted direction out of a blocking position. For example, if any ball that has passed the protrusions upwardly, moves back against the protrusions, as by falling back by gravity, the protrusions cannot move to allow passage of the ball (FIG. 1C). Thus, the one or more balls can flow into the basket but they can’t pass back out the back of the basket past the protrusions.

[0032] When the balls have been caught in the basket, the basket can be retrieved. For example, the basket can be retrieved using any of the various means for tool retrieval including pressure, tubing, wireline, etc., as noted above with respect to deployment. Alternately, a seal device can be launched, for example, and conveyed by gravity or pressure to latch onto the basket, for example into gland 20. The seal can then be actuated upon fluid pressure from below, to flow the seal device and the basket back to surface.

[0033] The ball catching device according to the present invention may be installed low down in well 22, at a position that can be reached by the balls during normal back flow. When positioning the ball catching device, the back flow driven movement of even the smallest balls should be considered, as they do not create a lot of hydraulic back pressure and tend to move the least. The ball catching device may be low down in the well for example, in the horizontal section, in the heel or in a lower vertical section of well 22.

[0034] In another embodiment, as shown in FIGS. 2 and 3, the ball catching device 100 may be incorporated in a tubing string 130 and positioned in a well 122 along with the tubing string. The tubing string may take various forms, but herein is shown as a frac string.

[0035] Ball catcher device 100 includes a main housing 112 with an inner open area 114 and one or more protrusions 116 in the inner open area moveably connected to the main housing. FIG. 2D shows a possible arrangement of protrusions circumferentially around the inner wall 112c of the main housing. The one or more protrusions are configured via their moveable connection to allow a ball to move upwardly therethrough in a direction toward surface. As shown in FIG. 3C, the one or more protrusions are also configured via their moveable connection to block any reverse movement of that ball 140, 115a, 115b downwardly therepast.

[0036] Inner open area 114 is sized to accommodate at least one ball 140, 115a, 115b to be caught by device 100.

[0037] Main housing 112 can take various forms, but at least supports an installation of the device in a tubing string. For example, main housing 112 may be formed as a tubular member having a bottom end 112a formed for accepting connection to a lower portion of string 130 and a top end 112b formed for accepting connection of an upper portion of string 130. The end may be formed by threading, quick connects, tapering, etc. to permit connection, depending on the form of the tubing string whether it be interconnected tubulars, coiled tubing, etc. Inner open area 114 may extend between and open at ends 112a, 112b such that area 114 is in open communication with inner bore 132 of the tubing string and fluid passing through the string’s inner bore 132 also passes through area 114. Protrusions 116 also allow fluid flow therepast.

[0038] Because the ball catching device is installed in tubing string 130 and, in this embodiment, the tubing string is used for wellbore operations including the passing of balls 115a, 115b therethrough, device 110 includes an activation mechanism 134 that allows the device to be maintained in an inactive position (FIG. 2A) and then activated to an active position (FIG. 2B). If the ball catching device is installed after any need to move balls down therepast, then a mechanism for activation need not be considered, as the device could be run in the active position without concern.

[0039] Activation mechanism 134 may take various forms and be operated in various ways. For example, in one embodiment, the protrusions may be held in an inactive position, retracted behind an openable sleeve 136. Protrusions 116 may be installed in or adjacent to an annular recess 138 opening from area 114 in the inner wall of main housing 112 and openable sleeve 136 may be positioned in the main housing open inner area 114 extending across at least the ends of protrusions 116, while the protrusions are positioned in the recess. With openable sleeve 136 overlapping protrusions 116, they are held in this retracted position (FIG. 2A). The device may be activated in numerous possible ways, including for example, hydraulic drives, physical manipulation from surface, signaling, or pressure drive, including by use of a timer, a conveyed tool such as a drop bar, plug (ball, dart, etc.), control line, hydraulic, electronic, etc. In one embodiment, for example, the frac string and/or the annulus could be pressurized to shift the sleeve away from the protrusions. In another embodiment, wireline or coiled tubing may be run in to shift the sleeve away and, thus, allow the protrusions to be released into an active position. In yet another embodiment, an electronic mechanism or radio signal can signal the protrusions to be released. The illustrated mechanism 134 allows openable sleeve 136 to be moved to release protrusions 116 by engagement of the sleeve with an activation ball 140 passing downwardly thereby. Sleeve 136, therefore, includes a seal 142 on its inner diameter sized to catch and create a seal with ball 140 such that pressure can be built up behind the ball sufficient to shift the sleeve away from its overlying position.
over protrusions 116. A shear pin 143 may be employed to releasably control the movement of the sleeve. In the illustrated embodiment, ball 140 is launched for the sole purpose of activating device 100. In particular, after ball 140 shifts sleeve 136 and pressure is reduced from surface, the ball can flow back from seat 142 through the (now activated) protrusions 116. A shear pin 143 may be employed to releasably control the movement of the sleeve. In the illustrated embodiment, ball 140 is then caught from falling back down into seat 142 in the same way as the other actuation balls are caught by protrusions 116. In another embodiment, the ball launched to activate the protrusions may also be the last ball needed to actuate a tool downhole of the ball catchers. For example, in a frac job, the ball, when launched, can cause the protrusions to be released as it passes them. Then the ball can pass to a frac port below the protrusions to open the frac port such that frac fluid can be flowed therethrough. In such an embodiment, the seat of the activation mechanism may be deformable to allow the ball to pass both downhole and back up such that the ball, when flowing back can reach and move through the protrusions. Thus, the activation ball can be used to conduct other wellbore processes or can be launched only for the purpose of actuating the ball catcher. In any event, ball 140 can be caught by the protrusions when it flows back.

In the active position, the protrusions are initially in a blocking position (FIG. 2C). When the well is flowed back, ball 140 and other actuation balls in the well below are able to come up through protrusions 116 into inner open area 114 between protrusions 116 and open top end 112b. Once above the protrusions, the balls cannot pass back down through the protrusions, as the protrusions block such movement. In particular, protrusions 116 are moveable between the blocking position and a position allowing upward movement of a ball therethrough. In the position allowing upward movement of a ball therethrough, the protrusions are pushed out of the way of a ball passing in a first direction up therethrough and, therefore, allow the ball to pass. In this operation, the protrusions move along arrow B in a direction out of the blocking position. However, protrusions 116 resist any movement from the blocking position to a position allowing downward movement of a ball therethrough, for example, such as if a ball, once above the protrusions, moves back against the protrusions, as by falling back by gravity.

Moveable connection 118 may incorporate various mechanisms to permit such protrusion operation including any of pivots, flexing members, sliders, etc. For example, as shown, moveable connection 118 includes a pivotal connection 144 on the base of each protrusion through which it is connected to the main housing wall. The protrusions, as permitted by their pivotal connections 144 can pivot radially outwardly or inwardly to increase or decrease, respectively, the space between the tips of the protrusions, which is the space through which the balls will travel. When the protrusions have applied thereto a force by a ball being pushed thereagainst from below, the protrusions can pivot up and out, arrow B, toward the housing walls to increase the space between the tips of protrusions 116. When the force is removed, the protrusions can pivot back in toward the center axis x, which decreases the space between the tips of protrusions 116. Thus, once the ball passes upwards through the protrusions, the protrusions fall back into the blocking position, and cannot pivot down beyond this position such that the protrusions resist downward movement of the ball.

It is noted that the protrusions in this illustrated embodiment may also be resilient to some degree to allow them (i) to be moved behind sleeve 136 and (ii) to pop out into an active position, when the sleeve is removed.

In operation, device 100 is installed in tubing string 130 which is runable from surface. In the string, device 100 is in a position to catch the balls. In a wellbore stimulation operation, a suitable tubing string may be referred to as a frac string. In a wellbore stimulation operation, a liner 150 may be set in the well 122. The stimulation of the formation 148 accessed by the wellbore may occur through the liner. The liner may be set by use of a liner hanger 154, liner packers 156, etc. and has an inner diameter 158 accessible through an uphole end. In this embodiment, liner 150 includes a plurality of fluid ports 160, included in tubular components commonly called frac ports 162, through which fluid can communicate between the annular area 164 about the liner and the liner inner diameter 158. The frac ports include valves controlling the open/closed position of the fluid ports. The valves are opened by and fluids are diverted through ports 160 by use of actuation balls 115a, 115b sized to land and seal in correspondingly sized seats. As described in the above-noted US patents, the balls can be graduated in size. A smallest ball 115a, for example, is used to actuate the lowest component in the liner, since that ball can pass through all the seats intended for larger balls before landing in its suitably sized seat.

The frac string is typically latchable at its distal end 130a onto the upper end 150a of the liner and, when desired, may be disconnected to be pulled to surface. The distal end can include a connecting point such as an on/off tool or a seal assembly.

Device 100 may be installed adjacent, for example, at or near, distal end 130a.

If the frac string in which device 100 is installed is to be used also during the stimulation operation, the protrusions 116 may initially be held in a retracted position (FIG. 3A), such that they do not affect the passage of balls 115a, 115b downwardly therepast. In one embodiment, the protrusions are configurable into a position that presents substantially no restriction in the string. For example, device 100 may include an activation mechanism 134, according to one of the embodiments described herein before. Activation mechanism 134 allows protrusions 116 to be initially retracted (FIG. 3A) and therefore inactive, and to be released into an active, ball catching position (FIG. 3B-3D) when it is appropriate.

For example, as noted above, the illustrated embodiment includes openable sleeve 136, which holds the protrusions in a retracted, inactive position. In particular, openable sleeve 136 extends partially or fully across an annular recess in which the protrusions are retracted when the string is run in to hold the protrusions in the recess. Thus, as far as the pressure containment is concerned, that string can have substantially full pressure containment and substantially no restrictions through inner diameter 132.

Device 100 is run in as part of the frac string 130. After connecting the frac string to liner 150, a stimulation job may be pumped through string 130 including conveying balls 115a, 115b, which can pass through the inactive ball catcher device, with protrusions 116 retracted.

After the job is run, before flow back is initiated, the device may be activated to position protrusions 116 into their blocking position such that the protrusions are available to catch balls 115a, 115b.

While the device may be activated in numerous possible ways, openable sleeve 136 in this embodiment, is moved to release the protrusions by engagement with a ball.
passing downwardly thereby. Ball 140 may be dropped and conveyed with fluid pressure arrow P toward sleeve 136 (FIG. 3A) and eventually lands in sleeve 136. The pressure differential generated when ball 140 lands in the seat of sleeve 136 causes the sleeve to shear loose and move to release protrusions 116, which pop out into the active, blocking position (FIG. 3B).

[0051] In the illustrated embodiment, ball 140 is launched only for the purpose of actuating the ball catcher. Ball 140 remains in the seat until flow back is initiated.

[0052] Once activated, protrusions 116 are in an active, blocking position which means balls can flow through in one direction only, that being toward surface. Back flow can then be initiated. While normally after a stimulation process, the frac string is pulled out of the well in order to put the well on production, the frac string in this case is left in place to accept back flowing fluid and to allow balls carried by the back flowing fluid to pass through bore 132 and reach device 100. With consideration as to the characteristics of the well, device 100 is in a position to be reached and passed through upwardly by ball 140 and at least some of balls 115a, 115b, as they are pushed along by back flow. However, once they pass the protrusions upwardly, the balls cannot reverse direction and go back down because of the protrusions 116 (FIG. 3C).

[0053] When at least some, and in this embodiment all, of the balls are above the protrusions of device 100, frac string 130 can be disconnected from the liner and pulled to surface (FIG. 3D). To pull the frac string out of the hole, the disconnect mechanism, such as on/off tool or seal assembly, is operated and then the frac string is pulled out of the hole (arrow POOH). Balls 140, 115a, 115b remain retained in the string above the protrusions and are, therefore, also retrieved to surface.

[0054] Since all the balls that passed upwardly through the protrusions are captured by ball catching device 100, the balls will also be removed from the well. As such, a ball-free liner 150 and well 122 is available if further operations are needed.

[0055] The well can be shut in before the frac string 150 is disconnected, if desired.

[0056] The protrusions are sized to retain the balls used in the well. For example, the protrusions may be selected with consideration as to the smallest balls to be retained, such that when the protrusions come together in the blocking position, any gaps therebetween are smaller than the smallest ball to be retained. The smallest ball may be the last one flowing back and may, therefore, be the ball directly above the protrusions.

[0057] In one embodiment, the protrusions may be formed and/or spaced in their housing such that fluid is mostly directed through one opening, as this will facilitate pushing balls up through the protrusions. To block flow except through a smaller opening, less than the full inner diameter, the protrusions can be closely positioned, overlapping, etc. For example, in one embodiment, protrusions 116 can be closely positioned adjacent their bases to block fluid flow adjacent inner wall 112, while an opening remains between tips 116a.

[0058] If the ball catcher tends to retain liquid when retrieved to surface, a bypass port may be provided to permit fluid to escape from above protrusions, and more likely balls, to prevent the development of a wet string. If the ball catcher is, as shown in FIGS. 2 and 3, formed in a tubing string, the bypass port may be normally closed but openable when desired. For example, with reference to FIG. 4, ball catching device 200 may be incorporated in a tubing string 230, which requires a pressure holding wall above, in and below device 200.

[0059] Ball catcher device 200 includes a main housing 212 with an inner open area 214 and one or more protrusions 216 in the inner open area moveably connected to the main housing 212. The one or more protrusions are configured through their moveable connection to allow balls 240a, 240b, 240c to move upwardly therethrough in a direction toward surface and to block any reverse movement of those balls downwardly therethrough.

[0060] Inner open area 214 is sized to accommodate the balls to be caught by device 200. If the size of the balls relative to ID of open area 214 is such that liquid cannot readily drain, arrows D, from area 214 down past the balls, a wet string may develop.

[0061] Housing 212 therefore can include a bypass port 260 that is an opening for fluid evacuation between inner area 214 and the outer surface 212f of the housing. Bypass port 260 has a closure 262 that permits the port to be opened with intent. Closure 262 is a sleeve in this embodiment, shiftable by hydraulic manipulation. For example, to open the bypass, a ball 264 may be launched from surface and is selected to apply a force to the closure to drive it open. In this embodiment, closure 262 includes a seat 262a onto which ball 264 can land FIG. 4D and generate a pressure to shift the closure down FIG. 4C. Once port 260 is open, liquid above the balls can drain out, arrows D'. The string, device and caught balls 240a, 240b, 240c and ball 264 can be pulled up without the inconvenience of a wet string.

[0062] Another embodiment of a ball catcher is shown in FIGS. 5 and 6. In this embodiment, ball catcher 300 is connected to bridge plug assembly 370 for installation in a well 322. Bridge plug assembly 370 includes a plurality of slips 372 and a seal 374 that can be engaged against the wall of the well. Bridge plug assembly 370 can be connected to a string 320 for manipulation including running in, setting and retrieval. Of course, the tool can be conveyed downhole by other means, as noted above.

[0063] Ball catcher device 300 includes a main housing 312 with an inner open area 314 and a protrusion 316 in the inner open area pivotally connected to the main housing 312. In this embodiment, the protrusion is in the form of a flapper and is configured via a pivotal connection 344 to be moveable up away from its seat 376 to allow a ball 340 to move upwardly therethrough in a direction toward surface. As shown in FIG. 6B, protrusion 316 is also configured, as by biasing, to pivot back down onto its seat 376 after the ball pushes past to block any reverse movement of that ball downwardly therethrough.


[0065] Inner open area 314 is sized to accommodate at least one ball to be caught by device 300.

[0066] Because the ball catching device can be installed after any wellbore operations to convey actuation balls 340, the protrusion of the device is always in the active position and does not have a mechanism for inactivation thereof.

[0067] In use, the tool including bridge plug assembly 370 and ball catching device 300 is run into a well and installed by setting the bridge plug including setting slips 372 and seal 374 (FIG. 6A). The tool is then in position to catch balls 340 from a treatment string 350. Seal 374 ensures that all produced fluids pass up through catcher 300, carrying the balls along with the flow. When balls enter area 314, they push up past
protrusion 216. After each ball passes, the protrusion is biased back down about connection 344 onto seat 376 to prevent the ball from reversing down past the protrusion.

[0068] Protrusion 316 doesn’t seal off the well, as fluid can continue to flow through apertures 378, even when the protrusion is seated.

[0069] When all the balls have been caught, the tool can be retrieved to surface carrying balls 340 therein (FIG. 63). In this embodiment, string 320 is trip'd in and connected to the upper end of the bridge plug. Bridge plug 370 is then manipulated to retract slips 372 and seal 374 and the string is pulled to pull the tool toward surface.

[0070] Balls 340 are caught by protrusion 316, but fluid can drain through apertures 378.

[0071] The previous description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to those embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the spirit or scope of the invention. Thus, the present invention is not intended to be limited to the embodiments shown herein, but is to be accorded the full scope consistent with the claims, wherein reference to an element in the singular, such as by use of the article “a” or “an” is not intended to mean “one and only one” unless specifically so stated, but rather “one or more”.

All structural and functional equivalents to the elements of the various embodiments described throughout the disclosure that are known or later to come to be known to those of ordinary skill in the art are intended to be encompassed by the elements of the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 USC 112, sixth paragraph, unless the element is expressly recited using the phrase “means for” or “step for”.

1. A downhole ball catcher for preventing an actuation ball migrating upwardly through a well from falling back down deeper into the well after passing upwardly through the downhole ball catcher, the downhole ball catcher comprising:

a main housing sized to be positioned downhole in the well and including a bottom end, a top end, an inner open area and openings for fluid flow from the bottom end, through the inner open area and out through the top end; and

a protrusion connected by a moveable connection to the main housing and positioned in the inner open area in a blocking position to block passage of a ball through the inner open area, the moveable connection being configured to allow movement of the protrusion away from the blocking position in response to a ball pushing upwardly past the protrusion toward the top end and the moveable connection being configured to resist movement of the protrusion away from the blocking position to prevent movement of the ball downwardly past the protrusion toward the bottom end.

2. The downhole ball catcher of claim 1 wherein the moveable connection includes at least one of a pivot, a flexing member or a slider/groove.

3. The downhole ball catcher of claim 1 wherein the moveable connection is resilient biasing the protrusion to the blocking position.

4. The downhole ball catcher of claim 1 further comprising a fishing structure for accepting engagement of a retrieval tool.

5. The downhole ball catcher of claim 1 further comprising a connection to a retrieval tool.

6. The downhole ball catcher of claim 1 wherein the top end is open and sized to allow the ball to pass.

7. The downhole ball catcher of claim 1 formed as a separate structure and independently positionable in the well.

8. The downhole ball catcher of claim 1 wherein the main housing is installed as part of a tubing string with the inner open area open to the tubing string's inner bore.

9. The downhole ball catcher of claim 8 wherein the tubing string is a frac string through which wellbore stimulation fluids are injected into the well.

10. The downhole ball catcher of claim 8 wherein the bottom end is formed for accepting connection to a lower portion of the string and the top end is formed for accepting connection of an upper portion of the string.

11. The downhole ball catcher of claim 1 further comprising an activation mechanism for maintaining the protrusion in an inactive position and operable to move the protrusion into an active position.

12. The downhole ball catcher of claim 11 wherein the activation mechanism an openable sleeve behind which the protrusion is retracted when in the inactive position.

13. The downhole ball catcher of claim 12 wherein openable sleeve is moveable by sliding to release the protrusion to assume the active position.

14. The downhole ball catcher of claim 12 wherein the openable sleeve includes a seat on its inner diameter sized to catch and create a seal with a ball such that pressure can be built up behind the ball sufficient to shift the sleeve to release the protrusion.

15. A wellbore assembly comprising:

an actuator ball in the well useful to actuate a downhole tool and moveable to migrate upwardly in the well as driven by backflow of wellbore fluids; and

an actuator ball catching device positioned in a lower portion of the well above the actuator ball, the device including a main housing with a fluid flow passage from a bottom end to an upper end and formed to be removable from the well by pulling to surface and the device having a mechanism to allow the passage of an actuator ball moving up through the device, the mechanism preventing the actuator ball from moving down past the device into the well.

16. The wellbore assembly of claim 15 wherein the mechanism includes a plurality of protrusions acting as a one-way valve for the actuator ball to allow movement of the actuator ball in an upward direction, while preventing movement of the actuator ball downward through the actuator ball catching device.

17. The wellbore assembly of claim 15 wherein the mechanism includes a protrusion connected by a moveable connection to the main housing and positioned in the inner open area in a blocking position to block passage of a ball through the inner open area, the moveable connection configured to allow movement of the protrusion away from the blocking position to allow movement of the actuator ball upwardly past the protrusion toward the top end and the moveable connection configured to resist movement of the at least one protrusion away from the blocking position to allow movement of the actuator ball downwardly past the protrusion toward the bottom end.
18. The wellbore assembly of claim 15 wherein the moveable connection includes at least one of a pivot, a flexing member or a slider/groove.

19. The wellbore assembly of claim 15 wherein the moveable connection is resilient biasing the protrusion to the blocking position.

20. The wellbore assembly of claim 15 further comprising a fishing structure for accepting engagement of a retrieval tool.

21. The wellbore assembly of claim 15 further comprising a connection to a retrieval tool.

22. The wellbore assembly of claim 15 wherein the top end is open and sized to allow the ball to pass.

23. The wellbore assembly of claim 15 formed as a separate structure and independently positionable in the well.

24. The wellbore assembly of claim 15 wherein the main housing is installed as part of a tubing string with the inner open area open to the tubing string’s inner bore.

25. The wellbore assembly of claim 24 wherein the tubing string is a frac string through which wellbore stimulation fluids are injected into the well.

26. The wellbore assembly of claim 24 wherein the bottom end is formed for accepting connection to a lower portion of the string and the top end is formed for accepting connection of an upper portion of the string.

27. The wellbore assembly of claim 15 further comprising an activation mechanism for maintaining the protrusion in an inactive position and operable to move the protrusion into an active position.

28. The wellbore assembly of claim 27 wherein the activation mechanism an openable sleeve behind which the protrusion are retracted when in the inactive position.

29. The wellbore assembly of claim 28 wherein openable sleeve is moveable by sliding to release the protrusion to assume the active position.

30. The wellbore assembly of claim 28 wherein the openable sleeve includes a seat on its inner diameter sized to catch and create a seal with a ball such that pressure can be built up behind the ball sufficient to shift the sleeve to release the protrusion.

31. A method for catching an actuation ball from a wellbore, the method comprising:

- positioning an actuator ball catching device downhole in a wellbore;
- backflowing wellbore fluids to push an actuator ball along the wellbore to the actuator ball catching device;
- catching the actuator ball by allowing the actuator ball to move up through the actuator ball catching device to the actuator ball catching device;
- the actuator ball moving up to the actuator ball catching device by preventing the actuator ball from falling back down into the well; and
- retrieving the actuator ball catching device from surface along with the actuator ball caught in the actuator ball catching device.

32. The method of claim 31 wherein the actuator ball catching device includes a protrusion acting as a one-way valve for the actuator ball and wherein during catching the actuator ball passes upwardly through the plurality of protrusions and thereafter cannot pass downwardly through the protrusions.

33. The method of claim 31 wherein positioning includes dropping the actuator ball catching device into the wellbore or running the actuator ball catching device into the wellbore using a string.

34. The method of claim 31 wherein positioning places the actuator ball catching device low down in the wellbore.

35. The method of claim 31 wherein the wellbore includes a liner installed therein and positioning places the actuator ball catching device adjacent the upper end of the liner.

36. The method of claim 35 wherein catching occurs upheole of the liner.

37. The method of claim 31 further comprising launching the actuator ball after positioning.

38. The method of claim 31 further comprising launching the actuator ball before positioning.

39. The method of claim 31 wherein retrieving uses a string or a pressure driven seal.

40. The method of claim 31 further comprising activating the actuator ball catching device after positioning.

41. The method of claim 31 wherein during positioning the actuator ball catching device is in an inactive condition and after positioning the method further comprises launching the actuator ball and activating the actuator ball catching device.

42. The method of claim 31 further comprising opening a drain port and allowing the fluid to drain from above the actuator ball caught in the actuator ball catching device.