A system includes a tubular string that is adapted to be deployed downhole in a well and an activation ball. The activation ball is adapted to be deployed in the tubular string to lodge in a seat of the string. The ball includes a spherical body, which is formed from a metallic material that has a specific gravity less than about 2.0.
START

DEPLOY METALLIC ACTIVATION BALL HAVING A SPECIFIC GRAVITY LESS THAN ABOUT 2.0 INTO TUBULAR STRING IN WELL

ALLOW BALL TO LODGE IN SEAT IN TUBULAR STRING

USE OBSTRUCTION CREATED BY BALL LODGING IN SEAT TO INCREASE FLUID PRESSURE IN TUBULAR STRING

USE INCREASED FLUID PRESSURE TO ACTIVATE DOWNHOLE TOOL

END

FIG. 2
METHOD AND APPARATUS FOR A WELL EMPLOYING THE USE OF AN ACTIVATION BALL

[0001] This application claims the benefit under 35 U.S.C. §119(e) to U.S. Provisional Patent Application Ser. No. 61/363,547 entitled, “ALLOY METALLIC ACTIVATION BALL,” which was filed on Jul. 12, 2010, and which is hereby incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] The invention generally relates to a method and apparatus for a well employing the use of an activation ball.

BACKGROUND

[0003] For purposes of preparing a well for the production of oil and gas, at least one perforating gun may be deployed into the well via a deployment mechanism, such as a wireline or a coiled tubing string. Shaped charges of the perforating gun(s) may then be fired when the gun(s) are appropriately positioned to form perforating tunnels into the surrounding formation and possibly perforate a casing of the well, if the well is cased. Additional operations may be performed in the well to increase the well’s permeability, such as well stimulation operations and operations that involve hydraulic fracturing, acidizing, etc. During these operations, various downhole tools may be used, which require activation and/or deactivation. As non-limiting examples, these tools may include fracturing valves, expandable underreamers and liner hangers.

SUMMARY

[0004] In an embodiment, a system includes a tubular string that is adapted to be deployed downhole in a well and an activation ball. The activation ball is adapted to be deployed in the tubular string to lodge in a seat of the string. The ball includes a spherical body, which is formed from a metallic material that has a specific gravity less than about 2.0.

[0005] In another embodiment, a technique includes deploying an activation ball in a downhole tubular string in a well. The activation ball includes a spherical body, which is formed from a metallic material that has a specific gravity less than about 2.0. The technique includes communicating the ball through a passageway of the string until the ball lodges in a seat of the string to form an obstruction (or fluid tight barrier); and using the obstruction to pressureize a region of the tubular string.

[0006] Other features and advantages will become apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWING

[0007] FIG. 1 is a schematic diagram of a well according to an embodiment of the invention.

[0008] FIG. 2 is a flow diagram depicting a technique using an activation ball in a well according to an embodiment of the invention.

[0009] FIGS. 3A, 3B and 3C are cross-sectional views of an exemplary ball activated tool.

[0010] FIG. 4 is a cross-sectional view of an activation ball in accordance with embodiments disclosed herein.

DETAILED DESCRIPTION

[0011] Systems and techniques are disclosed herein for purposes of using a lightweight activation ball to activate a downhole tool. Such an activation ball may be used in a well that is depicted in FIG. 1. For this example, the well 10 includes a wellbore 12 that extends through one or more reservoir formations. Although depicted in FIG. 1 as being a main vertical wellbore, the wellbore 12 may be a deviated or horizontal wellbore, in accordance with other embodiments of the invention.

[0012] As depicted in FIG. 1, a tubular string 20 extends into the wellbore 12 and includes packers 22, which are radially expanded, or “set,” for purposes of forming corresponding annular seal(s) between the outer surface of the tubular string 20 and the wellbore wall. The packers 22, when set form corresponding isolated zones 30 (zones 30a, 30b and 30c) being depicted in FIG. 1, as non-limiting examples, in which may be performed various completion operations. In this manner, after the tubular string 20 is run into the wellbore 12 and the packers 22 are set, completion operations may be performed in one zone 30 at a time for purposes of performing such completion operations as fracturing, stimulation, acidizing, etc., depending on the particular implementation.

[0013] For purposes of selecting a given zone 30 for a completion operation, the tubular string 20 includes tools that are selectively operated using activation balls 36. For the particular non-limiting example depicted in FIG. 1, the downhole tools are sleeve valves 33. In general, for this example, each sleeve valve 33 is associated with a given zone 30 and includes a sleeve 34 that is operated via an activation ball 36 to selectively open the sleeve 34. In this regard, in accordance with some embodiments of the invention, the sleeve valves 33 are all initially configured to be closed when run downhole. Referring to FIG. 3A in conjunction with FIG. 1, when closed (as depicted in zones 30b and 30c), the sleeve 34 covers radial ports 32 (formed in a housing 35 of the sleeve valve 33, which is concentric with the tubular string 30) to block fluid communication between a central passageway 21 of the tubular string 20 and the annulus of the associated zone 30. Although not shown in the figures, the sleeve valve 33 has associated seals (o-rings, for example) for purposes of sealing off fluid communication through the radial ports 32. The sleeve valve 33 may be opened by deployment of a given activation ball 36, as depicted in zone 30a of FIG. 1.

[0014] Referring to FIG. 3B in conjunction with FIG. 1, a given activation ball 36 is deployed from the surface of the well and travels downhole (in the direction of arrow “A”) through the central passageway 21 to eventually lodge in a seat 38 of the sleeve 34 and block a central passageway 39 of the sleeve valve 33. Referring to FIG. 3C in conjunction with FIG. 1, when lodged in the seat 38, an obstruction (or fluid tight barrier) is created, which allows fluid pressure to be increased (by operating fluid pumps at the surface of the well, for example) to exert a downward force on the sleeve 34 due to the pressure differential (i.e., a high pressure “P_h” above the ball 36 and a low pressure “P_w” below the ball 36) to cause the sleeve valve 33 to open and thereby allow fluid communication through the associated radial ports 32.

[0015] Referring to FIG. 1, in accordance with an exemplary, non-limiting embodiment, the seats 38 of the sleeve valves 33 are graduated such that the inner diameters of the
seats 38 become progressively smaller from the surface of the well toward the end, or toe, of the wellbore 12. Due to the graduated openings, a series of varying diameter activation balls 36 may be used to select and activate a given sleeve valve. In this manner, for the exemplary arrangement described herein, the smallest outer diameter activation ball 36 is first deployed into the central passageway 21 of the tubular string 20 for purposes of activating the lowest sleeve valve. For the example depicted in FIG. 1, the activation ball 36 that is used to activate the sleeve valve 33 for the zone 30a is thereby smaller than the corresponding activation ball 36 (not shown) that is used to activate the sleeve valve 33 for the zone 30b. In a corresponding manner, an activation ball 36 (not shown) that is of a yet larger outer diameter may be used to activate the sleeve valve 33 for the zone 30c, and so forth.

[0016] Although FIG. 1 depicts a system of varying, fixed diameter seats 38, other systems may be used in accordance with other embodiments of the invention. For example, in accordance with other embodiments of the invention, a tubular string may contain valve seats that are selectively placed in “object catching states” by hydraulic control lines, for example. Regardless of the particular system used, a tubular string includes at least one downhole tool that is activated by an activation ball, which is deployed through a passageway of the string. Thus, other variations are contemplated and are within the scope of the appended claims.

[0017] Removing a given activation ball 36 from its seat 38 may be used to relieve the pressure differential resulting from the obstruction of the passageway 37 (see FIG. 3C) through the sleeve valve 33. A seated activation ball 36 may be removed from the seat 38 in a number of different ways. As non-limiting examples, the activation ball 36 may be made of a drillable material so that activation ball 36 may be milled to allow fluid flow through the central passageway 21. Alternatively, the seat valve 38, the sleeve 34 or the activation ball 36 may be constructed from a deformable material, such that the activation ball 36 may be extruded through the seat 38 at a higher pressure, thereby opening the central passageway 21. As yet another example, the flow of fluid through the central passageway 21 may be reversed so that the activation ball 36 may be pushed upwardly through the central passageway 21 toward the surface of the well. In this manner, a reverse circulation flow may be established between the central passageway 21 and the annulus to retrieve the ball 36 to the surface of the well. By reversing fluid flow to dislodge the activation ball 36, the activation ball 36 is non-destructively removed from the well so that both the activation ball 36 and the corresponding sleeve valve may be reused.

[0018] When the activation ball 36 is retrieved by flowing fluid upwardly through the central passageway 21, the activation ball 36 may have a particular specific gravity so that upwardly flowing fluid can remove the activation ball 36 from the seat 38. While the specific gravity of the activation ball 36 may be a relatively important constraint, the activation ball 36 should be able to withstand the impact of seating in the seat 38, the building of a pressure differential across the ball 36 and the higher temperatures present in the downhole environment. The failure of the activation ball 36 to maintain its shape and structure during use may lead to failure of the downhole tool, such as the sleeve valve. For example, deformation of the activation ball 36 under impact loads, high pressure for high temperatures may conceivably prevent the activation ball 36 from properly sealing against the seat 38, thereby preventing the effective buildup of a pressure differential. In other scenarios, the deformation of the activation ball 36 may cause the activation ball 36 to slide through the seat 38 and to become lodged in the sleeve 34, such that it may be relatively challenging to remove the activation ball 36.

[0019] In embodiments where activation ball 36 is designed to be retrieved by flowing fluid upwardly through the central passageway 21, the activation ball 36 may have the following specific physical properties. Specifically, the activation ball 36 may have a particular specific gravity so that the upward flowing fluid can remove the activation ball 36 from the seat 38 and carry it upward through central passageway 21. While the specific gravity of the activation ball 36 may be a relatively important constraint, the activation ball 36 may also be able to withstand the impact of seating in the downhole tool, the building of a pressure differential across the activation ball 36, and the high temperatures of a downhole environment. Failure of the activation ball 36 to maintain its shape and structure during use may lead to failure of the downhole tool. For example, deformation of the activation ball 36 under impact loads, high pressures, or high temperatures may prevent activation ball 36 from properly seating against seat 38, thereby preventing the effective build up of a pressure differential. In other scenarios, deformation of the activation ball 36 may cause the activation ball 36 to slide through the seat 38 and to become lodged in the sleeve 34, such that conventional means of removing activation ball 112 may be ineffective.

[0020] Traditional activation balls may be solid spheres, which are constructed from plastics, such as for example, polyetheretherketone, or fiber-reinforced plastics, such as, for example, fiber-reinforced phenolic. While a traditional activation ball may meet specific gravity requirements, inconsistency in material properties between batches may present challenges such that the activation balls may be oversized so that their strength ratings, pressure ratings and temperature ratings are conservative. In accordance with embodiments of the disclosed herein, the activation ball 36 is a lightweight ball, which permits the ball 36 to have desired strength properties while being light enough to allow removal of the ball 36 from the well.

[0021] Referring to FIG. 2, thus, in accordance with some embodiments of the invention, a technique 50 includes deploying (block 52) a lightweight activation ball, such as a metallic activation ball that has a specific gravity less than about 2.0, into a tubular string in a well and allowing (block 54) the ball to lodge in a seat of the string. The technique 50 includes using (block 56) an obstruction created by the activation ball lodging in the seat to increase fluid pressure in the tubular string and using (block 58) the increased fluid pressure to activate a downhole tool.

[0022] Referring to FIG. 4, a cross-sectional view of an activation ball in accordance with embodiments disclosed herein is shown. Activation ball 200 includes a spherical body 202 formed from a metallic material, wherein the metallic material has a specific gravity less than about 2.0. In certain embodiments, the specific gravity of spherical body 202 may be between about 1.0 and about 1.9. The metallic material of spherical body 202 may be a metallic alloy such as, for example, beryllium alloy, aluminum alloy, or magnesium alloy. Beryllium alloys having a specific gravity of about 1.85, aluminum alloys having a specific gravity of about 2.8, and magnesium alloys having a specific gravity of about 1.8 may be used. A magnesium aluminum alloy may also be used, having a specific gravity of about 1.8.
A coating 206 may be disposed over an outer surface 204 of spherical body 202. Coating 206 may be formed from a corrosion resistant material such as, for example, polytetrafluoroethylene, perfluoroalkoxy copolymer resin, fluorinated ethylene propylene resin, ethylene tetrafluoroethylene, polyvinylidene fluoride, ceramic material, and/or an epoxy-based coating material. In certain embodiments, coating 206 may include Fluoron® 610-E, available from Southwest Impreglon of Houston, Tex.

Coating 206 may be applied to outer surface 204 of spherical body 202 using any method for applying a coating. For example, coating 206 may be applied to outer surface 204 of spherical body 202 by dipping spherical body 202 in the coating material, spraying the coating material onto outer surface 204, or rolling spherical body 202 in the coating material. A thickness, t, of coating 206 may be between about 0.001 and about 0.005 inches. Those of ordinary skill in the art will appreciate that multiple layers of coating material may be applied in stages until a desired thickness of coating 206 is achieved.

Alternatively, coating 206 may include a plating that is applied to outer surface 204 of spherical body 202 such as, for example, zinc plating, nickel plating, or chromium plating. In embodiments where coating 206 is a layer of plating, thickness, t, may be between about 0.001 and about 0.002 inches. In yet another embodiment, a surface treatment may be performed on surface 204 of spherical body 202 such as, for example, anodizing or a laser cladding treatment. Surface treatments may also be performed on an outer surface 206 of coating 206 to improve corrosion resistance, abrasion resistance, and surface finish. Activation ball 200 including coating 206 may have an overall specific gravity less than 2.00 and, in certain embodiments, the overall specific gravity of activation ball 200 may be between 1.00 and 1.85.

Advantageously, an activation ball formed from a metallic alloy in accordance with embodiments disclosed herein may provide increased bearing strength and impact resistance when compared with traditional activation balls formed from plastic or composite materials. Plastic and composite materials degrade quickly under high pressures and temperatures, and the degradation can be difficult to predict. In contrast, metallic alloys are able to withstand relatively high pressures and temperatures, and material properties of metallic alloys under high pressures and temperatures are well understood. As such, an activation ball in accordance with embodiments disclosed herein may be designed to withstand high temperatures and pressures without overdesigning to account for uncertainties in material behavior. Thus, an activation ball as disclosed herein may be more reliable than a plastic or composite activation ball, and may be more durable in a downhole environment.

Traditional activation ball materials such as plastics and composites are not easily plated or coated, and as such, a traditional activation ball is not protected from the high pressures and temperatures of a downhole environment. An activation ball in accordance with the embodiments disclosed herein having a spherical body formed from a metallic material can be coated, plated, and/or surface treated to improve properties such as impact and bearing strength, corrosion resistance, abrasion resistance, and surface finish. Because the behavior of metallic alloys under high pressures and temperatures is predictable, as discussed above, activation balls in accordance with the present application can be designed to have less contact area between the activation ball and a corresponding bearing area. As such, activation balls disclosed herein may allow for an increased number of ball activated downhole tools to be used on a single drill string. As a non-limiting example, by using an activation ball described above, approximately twelve fracturing valves (such as sleeve valve 34 (FIG. 1), for example) may be used during a multi-stage fracturing process, whereas approximately eight fracturing valves may be used in series with traditional activation balls.

While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed:
1. A system comprising:
   a tubular string adapted to be deployed downhole in a well,
   the string comprising a seat; and
   an activation ball adapted to be deployed in the tubular string to lodge in the seat, the ball comprising a spherical body formed from a metallic material having a specific gravity less than about 2.0.
2. The system of claim 1, further comprising a tool comprising the seat, wherein the ball is adapted to lodge in the seat to create an obstruction, where the tool is adapted to be activated in response to fluid pressure created due to the obstruction.
3. The system of claim 1, wherein the seat comprises one of a plurality of object catching seats of the string.
4. The system of claim 1, wherein the specific gravity is between about 1.00 and about 1.85.
5. The system of claim 1, wherein the metallic material comprises a metallic alloy.
6. The system of claim 5, wherein the metallic alloy is one selected from a group consisting of beryllium alloy, aluminum alloy, and magnesium alloy.
7. The system of claim 1, wherein the ball further comprises a coating disposed over the spherical outer surface of the ball.
8. The system of claim 7, wherein the coating comprises a material selected from a group consisting of polytetrafluoroethylene, perfluoroalkoxy copolymer resin, fluorinated ethylene propylene resin, ethylene tetrafluoroethylene, polyvinylidene fluoride, an epoxy-based coating material, and a ceramic material.
9. The system of claim 7, wherein a thickness of the material is between about 0.001 and 0.005 inches.
10. The system of claim 1, wherein the ball further comprises an anodized outer layer.
11. A method comprising:
   deploying an activation ball in a downhole tubular string in a well, the activation ball comprising a spherical body formed from a metallic material having a specific gravity less than about 2.0;
   communicating the ball through of the string until the ball lodges in a seat of the tubular string to form an obstruction; and
   using the obstruction to pressurize a region of the tubing string.
12. The method of claim 11, further comprising using the pressurization to activate a downhole tool.
13. The method of claim 11, wherein the communicating comprises flowing the ball through at least one other seat associated with a ball size larger than a size of the ball.

14. The method of claim 11, further comprising:
flowing the ball out of the seat and to the surface of the well.

15. The method of claim 11, wherein the metallic material has a specific gravity between about 1.0 and about 1.9.

16. The method of claim 11, wherein the ball further comprises a coating material adapted to cover an outer surface of the spherical body.

17. The method of claim 16, wherein the specific gravity of the spherical ball with the coating material is between about 1.0 and about 1.9.

18. The method of claim 11, wherein an outer surface of the spherical ball is surface treated.

19. The method of claim 18, wherein the surface treatment comprises at least one selected from a group consisting of an anodizing treatment, a nickel plating treatment, a chrome plating treatment, a ceramic coating treatment, and laser cladding treatment.

20. The method of claim 18, wherein the specific gravity of the surface treated spherical ball is between about 1.0 and about 1.9.

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