EXPANDABLE PLUG SEAT

Applicant: HydraWell Inc., Houston, TX (US)

Inventors: Martin P. Coronado, Cypress, TX (US);
Luis A. Garcia, Kingwood, TX (US);
Mark E. Plante, Tomball, TX (US);
Rodney D. Bennett, Houston, TX (US)

Filed: Oct. 23, 2015

Related U.S. Application Data
Provisional application No. 62/067,594, filed on Oct. 23, 2014.

Publication Classification
Int. Cl. E21B 23/01 (2006.01)

U.S. Cl.
CPC E21B 23/01 (2013.01)

ABSTRACT

Disclosed embodiments relate to methods and devices for setting a plug seat within a downhole well, for example in fracturing operations. In an embodiment, the expandable plug seat may include an expandable slip ring and one or more wedge rings. To set the expandable plug seat in place within the casing of the wellbore, longitudinal force would typically be applied to the one or more wedge rings, thereby deforming the expandable slip ring and driving it radially outward and into contact with the casing in the wellbore. In some embodiments, the expandable plug seat may be used with a dissolvable ball, which can be pumped to seat onto the plug seat device for sealing of the wellbore. Once the downstream section of the well has been isolated in this manner, hydraulic fracturing operations can commence. Eventually, the ball may dissolve, allowing access to the wellbore without the need to drill the plug.
Step 1: Plug is pumped to desired depth on wireline and setting tool.
Step 4: Wait predetermined period for plugs to disappear. Only solid-expandable slip and seals will remain. Continue with well startup and production activities.
EXPANDABLE PLUG SEAT
CROSS-REFERENCE TO RELATED APPLICATIONS


STATEMENT REGARDING FEDERAETALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

REFERENCE TO A MICROFICHE APPENDIX

[0003] Not applicable.

BACKGROUND

[0004] Conventional hydraulic fracturing operations (for drilled wells, such as oil and gas wells) typically use drappable zonal isolation devices (such as composite frac plugs) as the preferred method for treating and completing multi-zone horizontal wells. In application, such frac plugs would be located and set within the completion liner (e.g. cased well) one at a time. After placement of each frac plug, high pressure fracturing would be carried out in the reservoir upstream of the plug. Once all fracturing operations have been completed for the well, the plugs would then be drilled out to open the completion liner to production.

[0005] These conventional fracturing operations can be quite time consuming and costly, however. Additionally, there is the risk that it might not be possible to drill out the frac plugs located furthest in the toe of the horizontal well (e.g. furthest into the well and away from the head of the well), for example due to pipe lockup. In such instances, the operator would lose production for the intervals of the well not drilled out (resulting in a less efficient or productive well). The presently disclosed embodiments may solve one or more of these problems by providing an improved plugging technique, which may not require drill out in order to open the completion liner to full production. The presently disclosed embodiments may also provide for improved plug seat setting. Persons of ordinary skill in the art field will appreciate these and other possible benefits.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] For a more complete understanding of the present disclosure, reference is now made to the following brief description, taken in connection with the accompanying drawings and detailed description, wherein like reference numerals represent like parts.

[0007] FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3 illustrate two similar embodiments of an expandable plug seat, having a slip ring and two wedge rings, with FIG. 1A-1 illustrating the first embodiment of a plug seat in unset configuration, FIG. 1A-2 illustrating the plug seat of FIG. 1A-1 in set configuration, and FIG. 1A-3 illustrating a ball seated on the upper wedge ring of the set plug seat of FIG. 1A-2 (thereby sealing the wellbore); FIG. 1B-1 illustrates a second embodiment of a plug seat in an unset configuration, FIG. 1B-2 illustrates the plug seat of FIG. 1B-1 in a set configuration, and FIG. 1B-3 illustrates a ball seated on the upper wedge ring of the set plug seat of FIG. 1B-2 (thereby sealing the wellbore);

[0008] FIGS. 2A-1 through 2A-3 illustrates an exemplary plug seat device made-up into a tool string having a wireline-conveyed power charge setting tool (e.g. a wireline pressure setting assembly), with FIG. 2A-1 showing the top end view of the tool string when the plug seat is in its unset configuration, FIG. 2A-2 showing the longitudinal cross-section view A-A of the tool string, and FIG. 2A-3 showing a radial cross-sectional view B-B of the tool string in unset configuration; and FIG. 2B-1 showing the top end view of the tool string when the plug seat device is in its set configuration, FIG. 2B-2 showing the longitudinal cross-section view C-C of the tool string in its set configuration, and FIG. 2B-3 showing a radial cross-sectional view D-D of the tool string in set configuration;

[0009] FIGS. 3A-1 and 3A-2 and 3B-1 and 3B-2 illustrate an alternative embodiment of a plug seat, having a slip ring and only one wedge ring (along with additional elements), with FIG. 3A-1 showing an exterior side view of the plug seat in unset configuration and FIG. 3A-2 showing a partial cut-away cross-section view of the unset plug seat, and FIG. 3B-1 showing an exterior side view of the plug seat in set configuration and FIG. 3B-2 showing a partial cut-away cross-section view of the set plug seat;

[0010] FIGS. 4A-D illustrate schematically a method of employing the plug seat downhole, with FIG. 4A showing pumping the plug seat to desired depth on wireline and using a setting tool to set the plug seat in place, FIG. 4B illustrates perforating the desired zone above the set plug seat, dropping and pumping a ball to seal the wellbore at the plug seat, and conducting fracturing operations in the well above the set plug seat, FIG. 4C shows how this process may be repeated multiple times until all desired zones of the well have been fractured, and FIG. 4D illustrates how over time the dissolvable ball may dissolve to open the completion liner (e.g. cased wellbore) to production;

[0011] FIGS. 5A-1 through 5A-4 and FIGS. 5B-1 through 5B-4 illustrate yet another alternative embodiment of a plug seat, having a slip ring and two wedge rings similar to FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3 (but for example, optionally without an external seal on the slip ring), with FIG. 5A-1 showing a partial cut-away cross-section view of an exemplary tool string with the plug seat in unset configuration, FIG. 5A-2 showing a cross-section of the tool string of FIG. 5A-1, FIG. 5A-3 showing a side view of the unset plug seat of FIG. 5A-1, and FIG. 5A-4 showing a cross-section view of the unset plug seat of FIG. 5A-3; and FIG. 5B-1 showing a partial cut-away cross-section view of the exemplary tool string with the plug seat in set configuration, FIG. 5B-2 showing a side view of the plug seat of FIG. 5B-1 (after application of sufficient force on the wedge rings deforms the slip ring outward into set configuration), FIG. 5B-3 showing a cross-section view of the plug seat of FIG. 5B-2, and FIG. 5B-4 showing a cross-section view of the plug seat of FIG. 5B-3 with a ball seated on the upper wedge ring of the plug seat (thereby blocking fluid flow through the longitudinal bore of the plug seat and/or the cased wellbore in which the plug seat is set/affixed); and

[0012] FIGS. 6A-1 through 6A-3 and 6B-1 through 6B-3 illustrate still another alternative embodiment of a plug seat, having a slip ring and only one wedge ring, with FIG. 6A-1 showing a partial cut-away cross-section view of an exem-
ploy tool string with a plug seat in the unset configuration, FIG. 6A-2 shows a side view of the unset plug seat of FIG. 6A-1, and FIG. 6A-3 shows a cross-section of the unset plug seat of FIG. 6A-2; and FIG. 6B-1 showing a cross-section of the set plug seat (after application of sufficient force on the wedge ring deforms the slip ring outward into set configuration), and FIG. 6B-2 shows a cross-section of the set plug seat of FIG. 6B-1 with a ball seated on the wedge ring of the plug seat (thereby blocking fluid flow through the longitudinal bore of the plug seat and/or the cased wellbore in which the plug seat is set/affixed).

DETAILED DESCRIPTION

[0013] It should be understood at the outset that although illustrative implementations of one or more embodiments are illustrated below, the disclosed systems and methods may be implemented using any number of techniques, whether currently known or not yet in existence. The disclosure should in no way be limited to the illustrative implementations, drawings, and techniques illustrated below, but may be modified within the scope of the appended claims along with their full scope of equivalents.

[0014] The following brief definition of terms shall apply throughout the application:

[0015] The term “up,” “uphole,” “above”, or the like, when used in reference to well or the tool string for example, shall mean towards the surface or towards the top or away from the end/toe of the well; similarly, the term “down,” “downhole”, “below”, or the like shall mean away from the surface or towards the bottom or end/toe of the well;

[0016] The term “ring” shall, when used in reference to an element for use within a well or tool string for example, typically mean that the element has a hole, opening, or longitudinal bore therethrough (for example, of the sort which might allow fluid flow through the element), and typically such bore would be located approximately along the central (longitudinal) axis of the element;

[0017] The term "comprising" means including but not limited to, and should be interpreted in the manner it is typically used in the patent context;

[0018] The phrases “in one embodiment,” “according to one embodiment,” and the like generally mean that the particular feature, structure, or characteristic following the phrase may be included in at least one embodiment of the present invention, and may be included in more than one embodiment of the present invention (importantly, such phrases do not necessarily refer to the same embodiment);

[0019] If the specification describes something as “exemplary” or an “example,” it should be understood that refers to a non-exclusive example;

[0020] The terms “about” or approximately” or the like, when used with a number, may mean that specific number, or alternatively, a range in proximity to the specific number, as understood by persons of skill in the art field (for example, +/-10%); and

[0021] If the specification states a component or feature “may,” “can,” “could,” “should,” “would,” “preferably,” “possibly,” “typically,” “optionally,” “for example,” “often,” or “might” (or other such language) be included or have a characteristic, that particular component or feature is not required to be included or to have the characteristic. Such component or feature may be optionally included in some embodiments, or it may be excluded.

[0022] Embodiments may relate generally to methods and devices for setting a plug seat within a downhole well, for example in advance of fracturing operations. The disclosed expandable plug seat embodiments typically include an expandable slip ring (which in some embodiments may optionally have an elastomeric seal on its exterior) and one or more wedge rings (and in some embodiments, the plug seat may consist essentially of or consist only of a slip ring and one or more wedge rings). For example, typical embodiments might include dual wedge rings, with an upper wedge ring located above the slip ring and a lower wedge ring located below the slip ring. In other embodiments, a single wedge ring might be located with respect to (for example, above) the slip ring. To set the expandable plug seat in place within the casing of the wellbore, longitudinal force would typically be applied to each of the one or more wedge rings, thereby deforming the expandable slip ring and driving it radially outward and into contact with the casing in the wellbore (due to the interaction of the wedge-like shape of the one or more wedge rings with the inner (radial) surface of the slip ring). In some embodiments, deformation of the slip ring may be plastic and/or elastic (and most typically there would be plastic deformation of the slip ring). In some embodiments, the expandable plug seat may be used with a dissolvable ball (which might be either dissolvable metal or dissolvable polymer), which can be pumped to seat onto the plug seat device (for example, directly on the upper wedge ring). Once the downstream section of the well has been isolated in this manner, hydraulic fracturing operations can commence. Eventually, the ball may dissolve, allowing access to the wellbore without the need to drill the plug. And in some embodiments, one or more element of the plug seat may also dissolve, providing additional radial space in the well (for example, for future production).

[0023] So for example, in an embodiment, the plug seat device might comprise an expandable (for example, solid) slip ring (which optionally may have an external elastomeric seal), wherein the expandable slip ring is operable to expand by deforming (plastically and/or elastically) radially outward (upon application of sufficient force on its inner diameter); and one or more wedge rings (for example, operable to slide longitudinally and) located with respect to the slip ring so that application of sufficient longitudinal force on the wedge rings operates to drive the slip ring radially outward (e.g. causing the deformation of the slip ring). Typically, each wedge ring would comprise a wedge-like shape (for example, with the outer diameter of the wedge ring at one end (typically the end farther away from the slip ring in the unset configuration) being larger than the outer diameter of the wedge ring at the opposite end (typically the end closer to the slip ring in the unset configuration)) having an angled vertex/outer surface ranging from about 5-10 degrees (or alternatively 3-20 degrees), for example. And, the slip ring typically would be operable to deform (plastically and/or elastically) radially outward upon application of force from the wedge rings (for example, when sufficient longitudinal force is applied to the one or more wedge rings, driving the one or more wedge rings further into the slip ring, and thereby driving the slip ring radially outward due to the wedge-shape of the wedge rings). Furthermore, the expandable plug seat typically would have an (initial) unset configuration and a set configuration (e.g. after application of sufficient longitudinal force on the wedge rings has driven the slip ring radially outward into contact with the inner surface of the casing and/or wellbore, or until
the slip ring has been driven outward so that its outer diameter is approximately equal to the inner diameter of the cased wellbore in question. In the unset configuration, the slip ring typically has an initial outer diameter that is less than the inner diameter of the casing and/or wellbore (for example, allowing the plug seat device to be run downhole); one wedge ring (e.g. the upper wedge ring) is typically located above the slip ring; and optionally one wedge ring (e.g. the lower wedge ring) may be located below the slip ring, for example with (only) the vertex of each wedge ring initially being located within (e.g. radially inward of) and contacting the inner diameter/surface of) the slip ring (such that the remainder of the wedge rings typically would be located outside the slip ring and would not contact the slip ring in the unset configuration). So, the plug seat would be transitioned from its unset configuration to its set configuration by application of sufficient longitudinal force on the one or more wedge rings (for example, sliding the wedge rings longitudinally towards each other and/or inward of the slip ring—for example, with more of the wedge ring(s) located within the slip ring). In the set configuration, the one or more wedge rings would have been driven (and are located) further within the slip ring (for example, with the upper wedge ring being driven downward into the slip ring and the lower wedge ring being driven upward into the slip ring), thereby driving the slip ring radially outward via deformation (plastic and/or elastic) of the slip ring until the outer diameter of the slip ring contacts the inner diameter of the casing and/or wellbore with sufficient force to hold the slip ring in place during fracturing operations (e.g. the outer diameter of the slip ring in the set configuration is approximately equal to and contacts the inner diameter of the casing and/or wellbore). In other words, the slip ring may be set (e.g. moved from the unset configuration to the set configuration) by application of sufficient longitudinal force on the one or more wedge rings, driving the one or more wedge rings longitudinally further within the slip ring. Thus, the slip ring is configured so that it is operable to transition from its unset position/shape/size (with an outer diameter less than the inner diameter of the cased wellbore, for example) to its set position/shape/size (with outer diameter equal to the inner diameter of the cased wellbore, for example).

[0024] The slip ring may optionally have a plurality of anchoring teeth on its outer surface, configured to more securely attach the slip ring in place on the inner surface of the cased wellbore (in the set configuration), for example with the teeth operable/configured to penetrate the casing slightly upon setting of the plug seat (for example, penetrating about 0.010-0.030 inches). The slip ring may optionally also have a plurality of longitudinal slots (which typically might not penetrate all the way through the slip ring, but merely would be indentations forming a thinner wall cross-section at locations in the slip ring—although in other embodiments, the slots could form openings in the slip ring) which may be located radially around the circumference of (e.g. the outer surface) of the slip ring. For example, each such longitudinal slot might have a width of about 0.25 inches, a length of about 2.17 inches, and a depth to not fully penetrate the slip ring, but rather to leave a thin web (for example about 0.030 inches thick). An exemplary embodiment might have about 15 such slots spaced evenly around the exterior circumference of the slip ring. And while some embodiments of the slip ring may have an elastomeric (or other) seal element located on its outer/outer surface, in other embodiments the slip ring may be configured to effectively form a seal when driven into contact with the cased wellbore (e.g. an effective seal might be formed without the use of any such separate seal element).

[0025] Typically, the plug seat device does not contain any additional retention elements (such as a body lock ring or mandrel) beyond the slip ring and/or wedge rings (so for example, the plug seat may consist essentially of or consist of only the slip ring and one or more wedge rings). Additionally, typically the plug seat device would not contain a separate ball seat (e.g., the ball could be landed directly on the upper wedge ring). So for example, the plug seat of some embodiments might consist essentially of (or consist of) only the slip ring and one or more wedge rings. In some embodiments, the slip ring may comprise an outer surface, which may comprise a plurality of anchoring teeth/barbs/ridges in some embodiments for securing/attaching/anchoring the slip ring in place on the inner surface of the casing and/or wellbore (providing a better lock/grip than friction alone). Additionally, the optional elastomeric seal (typically located on the outer/external surface of the slip ring in embodiments having such a seal) typically would be configured/operable to effectively seal fluid flow about the exterior of the plug seat device when set in place within the casing (although in other embodiments, such an effective seal might be formed by contact of the slip ring body itself against the cased wellbore, without any need for a separate seal element). Typically, the optional seal diameter would be slightly larger than the outer diameter of the slip ring (for example, larger than the slip teeth diameter) to allow for compression when set. Such a seal might be rated for 10,000 psi differential pressure at 350 degrees Fahrenheit. Exemplary seal materials might be either Nitrile or Atlas.

[0026] Often, the plug seat device might be operable or configured to work in conjunction with a sealing ball/plug. Such a ball might be formed of a dissolvable material (which might be metallic or polymeric material operable to dissolve over time (for example, approximately 1-5 days) under exposure to elevated temperature (for example a range of approximately 150-250 degrees Fahrenheit) and either brine (for example KCl brine) or acid (for example approximately 2-5 pH range)). One example of such a dissolvable material might be TervAlloy or similar materials sold by Tervex, Inc. Another example of such dissolvable material might be polymer from Bubblemight L.L.C. In some such embodiments, the slip ring and/or one or more wedge rings in the set configuration might be configured to have an inner diameter sufficiently large to allow for access to the wellbore via tubing or wireline (such that they do not need to be drilled out to allow for production of the well). In some other embodiments, the one or more wedge rings and/or the slip ring of the plug seat might also be formed of such dissolvable material (e.g. material operable to dissolve over time (for example, approximately 1-5 days) under exposure to elevated temperature (for example a range of approximately 150-250 degrees Fahrenheit) and either brine (for example KCl brine) or acid (for example approximately 2-5 pH range)). For example, the one or more wedge rings and/or slip ring might be formed of the same dissolvable material as the sealing ball/plug. This would allow the plugged wellbore to open (after the timeframe needed for fracturing, for example) without the need for drilling. And in some embodiments, the plug seat device may be configured/operable to be made-up into a tool string with a wireline-conveyed power charge setting tool (e.g. a wireline pressure setting assembly) and/or a perforating gun assembly. Such a
tool string may allow the plug seat to be set and the wellbore to be perforated in one wireline trip downhole (e.g. prior to fracturing the zone).

[0027] FIGS. 1A-1 through 1A-3 illustrate a first embodiment of a plug seat device 10, while FIGS. 1B-1 through 1B-3 illustrate a second, similar embodiment of a plug seat device (with the primary difference between the embodiments of FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3 being the angle of the wedge rings and/or the depth that the wedge rings slide within the slip ring during setting). FIG. 1A-1 illustrates an exemplary plug seat device 10 in its unset configuration (e.g. its initial configuration, allowing it to be run downhole into position within the wellbore). The plug seat device of FIG. 1A-1 has a slip ring 20 and two wedge rings 30 and 40. The slip ring 20 of FIG. 1A-1 is configured as a solid ring operable to deform (e.g. plastically and/or elastically) radially outward upon application of force from the wedge rings (e.g. when sufficient longitudinal force is applied to the wedge rings), and in the unset configuration of FIG. 1A-1, the slip ring 20 has an outer diameter that is less than the inner diameter of the casing/wellbore 5 (to provide sufficient clearance so that the plug seat can be run downhole). For example, when the wedge rings 30, 40 (each of which may be operable to slide longitudinally upon application of sufficient longitudinal force) are driven towards the slip ring 20 (longitudinally), the angled surfaces of the wedge rings 30, 40 would drive the slip ring 20 radially outward and into contact with the wellbore/casing 5. By way of example, the slip ring 20 of FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3 might be formed of AISI 8620 material (fully annealed, 10-12% elongation, which should provide sufficient plasticity to allow for the slip ring to transition from the unset configuration/position to the set configuration/position. The slip ring 20 of FIG. 1A-1 typically has an elastomeric seal 22 (although this may be optional) about its outer/exterior surface (for example, extending circumferentially about the exterior of the slip ring), and the elastomeric seal 22 is configured/enableable of providing an effective seal to prevent fluid flow about the exterior of the slip ring 20 in its set configuration. Furthermore, the slip ring of FIG. 1A-1 typically would have a plurality of gripping or anchoring elements 25 (typically termed teeth) on its exterior surface (for example, teeth, barbs, or ridges operable to bite/dig into the inner diameter surface of the casing/wellbore 5 when the plug seat is set, to provide a more effective hold to lock the plug seat in place).

[0028] In the embodiment of FIG. 1A-1, the two wedge rings 30 and 40 each typically have an angle of about 10 degrees (so for example, the outer surface of the wedge rings might have an angle of about 10 degrees with respect to a line parallel to the centerline of the plug seat device). Typically, in the unset configuration shown in FIG. 1A-1, one wedge ring would be located on either side of the slip ring 20 (for example, with an upper wedge ring 30 located above the slip ring 20, and the lower wedge ring 40 being located below the slip ring 20), and typically only the vertex 32, 42 of the wedge rings would be located initially within the slip ring 20 and contacting the inner surface of the slip ring (e.g. the remainder of the wedge rings 30, 40 would initially be located outside the slip ring, for example longitudinally). In other words, there is a gap of space longitudinally between the vertexes of the wedge rings 30 and 40 in the unset configuration (and the gap typically would be approximately the length of the slip ring 20). And typically, the wedge rings 30, 40 would have an outer diameter that at their furthest end is less than the inner diameter of the casing/wellbore 5 (to again ensure that the plug seat device as a whole has an outer diameter that is less than the inner diameter of the casing/wellbore 5, so that there is sufficient clearance to allow for running of the plug seat device downhole). For example in the unset configuration the outer diameter (of the far end of) the wedge rings 30, 40 would typically be spaced away from the inner diameter of the casing/wellbore 5 about a distance less than the thickness of the slip ring 20). By way of example to the wedge rings 30, 40 would typically be formed of a material which is sufficiently strong to drive the slip ring outward (under application of sufficient longitudinal force), such as AISI 4140 material with 110 minimum yield strength.

[0029] FIG. 1A-2 illustrates the same plug seat device from FIG. 1A-1 in its set configuration (e.g. after application of sufficient longitudinal force on the wedge rings, to drive the slip ring radially outward and into contact with the casing/wellbore, thereby fixing the plug seat 10 into position in the well). Longitudinal force typically would be applied to the top of the upper wedge ring 30 and to the bottom of the lower wedge ring 40, thereby driving the wedge rings closer together and further into the slip ring 20. By way of example, the setting longitudinal force for some embodiments might be approximately 10,000-30,000 lbs-F. As the wedge rings 30, 40 are driven inward, their angled surfaces act to transmit the force to the slip ring 20, thereby driving the slip ring 20 radially outward until it contacts and is set in the casing/wellbore 5. So in FIG. 1A-2 (which shows the plug seat in its set configuration), the wedge rings 30, 40 are closer together, with more of the wedge rings 30, 40 length located within the slip ring 20. The slip ring 20 of FIG. 1A-2 has a larger outer diameter, which is approximately equal to the inner diameter of the casing/wellbore 5. This allows the anchoring teeth 25 on the exterior surface of the slip ring to anchor securely to the casing/wellbore 5 (in a securely affixing manner), and the elastomeric seal 22 on the exterior of the slip ring 20 to fit snugly (in a sealing manner) against the inner surface of the casing/wellbore 5.

[0030] FIG. 1A-3 then shows how the open longitudinal bore of the set plug seat device 10 may be sealed by seating a ball 50 onto the upper wedge ring 30. This would typically be done in advance of fracturing operations upstream of the plug seat 10. The ball 50 would typically have a diameter larger than the inner diameter of the wedge ring 30, and would typically seat directly onto the upper wedge ring 30. In some embodiments, the ball 50 would be formed of dissolvable materials. For example, the ball 50 might be formed of dissolvable metallic material operable to dissolve over time (for example, approximately 1-5 days) under exposure to elevated temperature (for example a range of approximately 150-250 degrees Fahrenheit) and either brine (for example KCL brine) or acid (for example approximately 2-5 pH range). One example of such a material might be TervAlloy or similar materials sold by Terves, Inc. Alternatively, the ball might be made of a dissolvable polymer material, such as made by Bubblegym LLC for example. In some embodiments, the ball might have a protective coating, for example to delay dissolution of the ball (although in other embodiments, the well chemistry might be used (perhaps along with a protective coating) to delay or control the timing of dissolution). The use of such a dissolvable ball 50 might allow for the plug seat 10 to be temporarily sealed by a ball, but to be operable to open at a later time without the need for drilling. In some embodi-
ments, the wedge rings 30, 40 and/or slip ring 20 might also be formed of similar dissolvable materials (which might allow for a larger bore without the need for drilling).

[0031] FIGS. 1B-1 through 1B-3 illustrate a similar plug seat 10, having wedge rings 30, 40 with an angle of about 5 degrees (e.g., the outer surface of the wedge rings would have an angle of about 5 degrees with respect to a line parallel to the centerline of the plug seat 10). FIG. 1B-1 shows the plug seat in unset configuration. FIG. 1B-2 shows the plug seat in set configuration, and FIG. 1B-3 shows the plug seat when sealed by a ball 50. In FIG. 1B-2, the wedge rings 30, 40 may be driven together until their vertices contact. It should be understood that sufficient longitudinal force applied to the wedge rings may effectively set the slip ring in the casing/wellbore, as discussed above.

[0032] In some embodiments, the plug seat 10 (for example as shown in FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3, although other plug seat embodiments would also apply) may be made-up into a tool string having a wireline-conveyed power charge setting tool (e.g., a wireline pressure setting assembly, such as Baker Style #20 WI Setting Tool), for applying the longitudinal force required to set the plug seat 10 in place in the casing/wellbore. For example, FIGS. 2A-1 through 2A-3 and 2B-1 through 2B-3 illustrates such an exemplary tool string, with FIG. 2A-1 through 2A-3 showing the tool string when the plug seat 10 is in the unset configuration, and FIG. 2B-1 through 2B-3 showing the tool string when the plug seat 10 is in the set configuration. FIG. 2A-1 shows a top side view of the tool string in unset configuration, while FIG. 2A-2 shows a longitudinal cross-sectional view A-A (showing the plug seat device 10 in unset configuration and in place in line with the setting tool 60), and FIG. 2A-3 shows a radial cross-sectional view B-B. FIG. 2B-1 shows a top side view of the tool string in set configuration, while FIG. 2B-2 shows a longitudinal cross-sectional view C-C (showing the plug seat device 10 in set configuration and in place in line with the setting tool 60), and FIG. 2B-3 shows a radial cross-sectional view D-D. In some embodiments, the tool string may also include a perforating gun (not shown, but for example, located above the plug seat 10). Such a tool string configuration might allow setting of the plug seat and perforating of the well using only a single trip downhole (prior to fracturing the zone). Then, for example, a dissolvable ball might be seated on the plug seat to allow for fracting operations (for example, during the time before the ball and/or wedge rings dissolve).

[0033] FIGS. 3A-1 through 3A-2 and 3B-1 through 3B-2 illustrate an alternative embodiment of a plug seat. The plug seat of FIGS. 3A-1 through 3A-2 and 3B-1 through 3B-2 comprises a dissolvable mandrel or body, a dissolvable tapered cone/wedge ring (similar to that discussed above), a dissolvable lock ring, and/or a solid expandable slip ring (similar to the slip ring discussed above) having an inner seal and an outer seal (although such seals may be optional, with one or both being omitted from some embodiments). The dissolvable materials might be the same or similar to those discussed above, for example. As described above, the wedge ring/cone would typically have a wedge-like portion having an angled outer surface (for example, ranging from about 3-20 degrees). The mandrel has a flow-through passage, which may allow flow bypass prior to fracturing operations. The mandrel also features a ball seat on the uphole end. Typically, the mandrel would also comprise an angled outer surface portion located (below the slip ring) and oriented to work in conjunction with the wedge ring (when sufficient longitudinal force is applied to the wedge ring to drive the slip ring radially outward during setting of the plug seat (e.g., causing plastic deformation of the slip ring as it moves from the unset position to the set position). For example, in the embodiment of FIGS. 3A-1 through 3A-2 and 3B-1 through 3B-2 the angled outer surface portion of the mandrel typically might match the angle of the wedge ring and/or be 3-20 degrees. Similar to the embodiments described above, the plug seat of FIGS. 3A-1 through 3B-1 through 3B-2 has an initial, unset configuration, and a set configuration. FIGS. 3A-1 through 3A-2 show the plug seat in its unset configuration, while FIGS. 3B-1 through 3B-2 show the plug seat in its set configuration. To set the plug seat in place in the wellbore, a longitudinal force would be applied to the dissolvable lock ring and/or tapered cone/wedge ring while the mandrel is held in place. The force would serve to deform (e.g., plastically and/or elastically) the expandable solid slip ring, driving it radially outward until it contacts the inner diameter of the casing/wellbore. Once the plug seat is anchored, a dissolvable ball (which, for example, might be formed of the same dissolvable material as the dissolvable elements of the plug seat) may be dropped and pumped to seat on the mandrel (e.g., the ball seat) of the plug seat, to allow for fracturing operations. Over time, the dissolvable elements of the plug seat (and the ball) will dissolve, for example leaving only the slip ring and/or seals behind (which should not inhibit production flow and typically would have a sufficiently large inner diameter to allow for access to the wellbore via tubing and/or wireline). In other embodiments, however, even the slip ring might be formed of dissolvable material (for example, similar to that described above), such that only the elastomeric seals (if any) might be left undissolved in the wellbore. In some embodiments, the ball and/or dissolvable elements of the plug seat device might have a protective coating, for example to delay dissolution (although in other embodiments, the well chemistry might be used (perhaps along with a protective coating) to delay or control the timing of dissolution).

[0034] FIGS. 5A-1 through 5A-4 illustrate an alternative embodiment of a plug seat (similar to that shown in FIGS. 1A-1 through 1A-3 and 1B-1 through 1B-3 for example) in unset configuration, while FIGS. 5B-1 through 5B-4 illustrate the same embodiment in set configuration. FIGS. 5A-1 and 5A-2 illustrate the plug seat 510 within an exemplary tool string (e.g., the plug seat may be removably coupled to the tool string, for example with a wireline-conveyed power charge setting tool), with FIG. 5A-1 showing a partial cut-away cross-section view of the tool string and FIG. 5A-2 showing a full cross-section of the tool string (in unset configuration). FIG. 5A-3 illustrates (in a side view) just the plug seat 510 in unset configuration, while FIG. 5A-4 illustrates the same unset plug seat 510 via cross-section view. So as clearly shown in FIGS. 5A-3 through 5A-4, the plug seat 510 has two wedge rings 530 and 540 configured to interact (via longitudinal sliding) with the slip ring 520 (typically with one wedge ring 530 located above the slip ring 520, and one wedge ring 540 located below the slip ring 520). In other words, in FIG. 5A-4 (with the plug seat unset), only the vertex of each wedge ring 530, 540 is initially located within the slip ring 520, but the wedge rings 530, 540 are configured to slide further into the slip ring 520 upon application of sufficient longitudinal force (e.g., shifting from unset to set configuration).

[0035] The slip ring 520 in this unset configuration has an outer diameter which is configured to be less than the inner
diameter of the cased wellbore (for which the plug seat is intended to be used), and is operable/configured to deform (plastically and/or elastically) under application of force from the wedge rings 530, 540 (in order to shift outward from the unset to the set configuration/position). The wedge rings 530, 540 also have a maximum outer diameter which is less than the inner diameter of the cased wellbore (although typically the difference between the maximum outer diameter of the wedge rings 530, 540 and the inner diameter of the cased wellbore is less than or equal to the thickness of the slip ring, for example after deformation to the set position). In FIG. 5A-3, the slip ring 520 comprises a plurality of teeth 525 on its outer/exterior surface, typically located about the circumference of the slip ring outer surface. While the teeth 525 may be oriented in various ways (e.g. to form a secure hold onto the cased wellbore), in FIG. 5A-3 the teeth on the upper portion of the slip ring 520 face one direction (for example, angled downward), while the teeth on the lower portion of the slip ring 520 may face another direction (for example, angled upward). The wedge ring 630 also has a maximum outer diameter which is less than the inner diameter of the cased wellbore at issue. Additionally, embodiments may optionally include a shearing ring or tab (for example, attached to the slip ring and/or the lower wedge ring) in the unset configuration of FIG. 5A-1, which may be operable/configured to be sheared once the setting tool provides the required setting force. This may limit the amount of force applied to the plug seat, and may also allow for the plug seat to disconnect from the setting tool once set. Thus, these figures clearly illustrate an exemplary plug seat embodiment (for example, without an external elastomeric seal) in both the unset and set configuration, and persons of skill would understand the construction and operation of such a plug seat 510 based on these figures.

Figs. 5A-3 through 5B-3 illustrate another alternative embodiment of a plug seat (similar to that shown in Figs. 1A-1 through 1A-4 and 1B-1 through 1B-4 and/or Figs. 3A-1 through 3A-2 and 3B-1 and 3B-2 for example) in unset configuration, while Figs. 6A-1 through 6B-2 illustrate the same embodiment in set configuration. FIG. 6A-1 illustrates the plug seat 610 within an exemplary tool string (e.g. the plug seat may be removably coupled to the tool string, for example with a wireline-conveyed power charge setting tool), with FIG. 6A-1 showing a partial cross-section view of the tool string (in unset configuration). FIG. 6A-2 illustrates (in a side view) just the plug seat 610 in unset configuration, while FIG. 6A-3 illustrates the same unset plug seat 610 via cross-section view. So as clearly shown in FIGS. 6A-2 through 6A-3, the plug seat 610 has only one wedge ring 630 (typically located above the slip ring 620), which is configured to interact (via longitudinal sliding) with the slip ring 620. In other words, in FIG. 6A-3, only the vertex of the wedge ring 630 is initially located within the slip ring 620 (in unset configuration), but the wedge ring 630 is configured to slide further into the slip ring 620 upon application of sufficient longitudinal force (e.g. shifting from unset to set configuration).

Similar to the discussion above regarding FIGS. 5A-1 through 5A-4 and 5B-1 through 5B-4, the slip ring 620 in this unset configuration has an outer diameter which is configured to be less than the inner diameter of the cased wellbore (for which the plug seat is intended to be used), and is operable/configured to deform (plastically and/or elastically) under application of force from the wedge ring 630 (in order to shift outward from the unset to the set configuration/position). The wedge ring 630 also has a maximum outer diameter which is less than the inner diameter of the cased
wellbore (although typically the difference between the 
maximum outer diameter of the wedge ring 630 and the inner 
diameter of the cased wellbore is less than or equal to the 
thickness of the slip ring, for example after deformation to 
the set position). In FIG. 6A-3, the slip ring comprises a plurality 
of teeth 625 on its outer/exterior surface, typically located 
about the circumference of the slip ring outer surface. While 
the teeth 625 may be oriented in various ways (e.g. to form a 
secure hold onto the cased wellbore), in FIG. 6A-3 the teeth 
also face one direction (for example, angled downward). The 
slip ring 620 of FIG. 6A-3 also comprises a plurality of 
longitudinal slots 627 located evenly about its outer surface 
fir circumference. For example, in FIG. 6A-3, there may be up to 
15 such slots (which in this embodiment may penetrate the 
slip ring 620 forming openings through the slip ring, but 
which in other similar embodiments might merely be loca- 
tions of thickness of the slip ring, such as indentations), with 
each slot typically having a width of about 0.25 inches and a 
length of about 2.17 inches (and some embodiments having a 
slot depth penetrating the slip ring, while other embodiments 
might have a depth to not fully penetrate the slip ring, but 
leaving a thin web (for example about 0.050 inches)).

[0040] As discussed above, the slip ring 620 is typically 
made of a material operable to deform from unseen to set 
configuration upon application of sufficient force (radially) 
via the wedge ring 630. And typically, the wedge ring 630 
and/or the slip ring 620 may be formed of dissolvable material 
(as discussed above). On the other hand, if the wedge ring 
and/or slip ring are not dissolvable (for example, if only a 
dissolvable ball is used to close the bore), then they (e.g. one 
or both) may instead have a bore (e.g. an inner diameter) 
which is sufficiently large in the set position/configuration to 
allow for access to the wellbore (below the set plug seat) via 
tubing or wireline, such that they do not need to be drilled out 
to allow for downhill work/production below the set plug 
seat in the wellbore. And as discussed above, the wedge ring 
630 typically has a wedge-like shape (for example, in cross-
section), with the outer surface having an angle (for example, 
with respect to a line parallel to the longitudinal bore center-
line) ranging from about 30 degrees (or for example alter-
ately, 5-20, 5-10, or 10-20 degrees). And as discussed above, 
the seat plug of FIGS. 6A-1 through 6A-3 and 613-1 through 
615-2 may consist essentially of or consist of only the slip ring 
620 and wedge ring 630.

[0041] Upon application of sufficient longitudinal force on 
the wedge ring 630, for example with the setting tool pressing 
down on the upper wedge ring 630 directly, the wedge ring 
630 moves (e.g. slide longitudinally) further into the slip ring 
(for example, with most of the length of the wedge ring 
located within the slip ring), with the wedge-like shape driv-
ing the slip ring 620 to deform (plastically and/or elastically) 
outward to the set configuration/position as shown in FIGS. 
613-1 through 613-2 for example (when its outer diameter is 
configured to be approximately equal to the inner diameter of 
the cased wellbore, providing a secure attachment of the plug 
seat to the cased wellbore, as discussed above). FIG. 613-1 
illustrates in cross-section just the plug seat 610 (in set 
configuration), while FIG. 613-2 shows the set plug seat 610 
with a ball 650 (typically dissolvable) seated on the wedge ring 
630 to close/seal the bore (for example, in preparation for 
fracturing). In the set configuration shown in FIGS. 613-1-613-2, 
the wedge ring 630 has been driven farther into the slip ring 
and is substantially located within the slip ring 620. The slip 
ring 620 of FIG. 613-1 (in the set configuration) typically 
would have an outer diameter approximately equal to the 
inner diameter of the cased wellbore at issue. Additionally, 
embodiments may optionally include a shear ring or tab (for 
example, attached to the slip ring) in the unset configuration 
of FIG. 5A-1, which may be operable/configured to be 
shered once the setting tool provides the required setting 
force. This may limit the amount of force applied to the plug 
seat, and may also allow for the plug seat to disconnect from 
the setting tool once set. Thus, these figures clearly illustrate 
an exemplary plug seat embodiment (for example, without an 
external elastomeric seal) in both the unset and set configu-
ration, and persons of skill would understand the construction 
and operation of such a plug seat 610 based on these figures.

[0042] One or more of the plug seat device embodiments 
described above may allow for an improved method of frac-
turing a well, especially for example when used in conjunc-
tion with a dissolvable ball/plug. Typically, such a method of 
performing downhole operations (such as fracturing) within a 
typically cased) wellbore uses an expandable plug seat 
(which, for example, might include a slip ring and one or 
more wedge rings located with respect to the slip ring so that 
application of sufficient longitudinal force on the wedge rings 
operates to drive the slip ring radially outward) and includes 
the step of applying a longitudinal force onto the one or more 
 wedge rings (thereby driving the wedge rings towards one 
another and/or deeper into the slip ring), thereby deforming 
(e.g. plastically and/or elastically) the slip ring radially out-
ward into contact with the casing/wellbore (in order to seat 
the plug seat in the casing/wellbore and/or move the plug seat 
from the unset position to the set position). In some embodi-
ments, the longitudinal force may be applied to the wedge 
rings by a wireline-conveyed power charge setting tool (e.g. a 
wireline pressure setting assembly). Typically, the plug seat 
might not contain any additional retention elements (such as 
body lock ring or mandrel) beyond the slip ring and/or wedge 
ring(s). Additionally, the plug seat typically would not con-
tain a separate ball seat; rather, the ball would be landed 
directly on the upper wedge ring. So in some embodiments, 
the plug seat may consist essentially of (or consist of) only 
the slip ring and one or more wedge rings.

[0043] The method may further comprise the step of posi-
tioning the plug seat within the wellbore (i.e. locating the plug 
at the proper location downhole within the wellbore for seal-
ing of the wellbore for fracturing of a zone). Oftentimes, 
the plug seat may be run downhole in combination with a wire-
line-conveyed power charge setting tool (e.g. a wireline pres-
sure setting assembly) and/or a perforating gun assembly 
(e.g. all three would be run downhole together at the same 
time). This may allow for more efficient setting of the plug 
seat and perforating of the well (reducing the number of 
separate trips run downhole). Typically, such a method would 
include making-up a tool string comprising the plug seat, a 
wireline-conveyed power charge setting tool (e.g. a wireline 
pressure setting assembly), and/or a perforating gun assembly, 
and positioning the plug seat in the wellbore setting the 
plug seat using the wireline-conveyed power charge setting 
tool (e.g. a wireline pressure setting assembly), and perfor-
ating the well casing, all in a single trip downhole.

[0044] Once the plug seat has been set in the wellbore and 
the well/casing has been perforated, the wellbore can be 
sealed to allow for fracturing of the well upstream of the plug 
seat. Typically, the wedge rings may comprise at least an 
upper wedge ring located above the slip ring, and the method 
may further comprise landing (e.g. pumping) a dissolvable
ball/plug onto the upper wedge ring (to isolate/seal the down-
stream section of the well). In other words, the ball typically
would land directly on the upper wedge ring, without a sepa-
rate ball seat. In some embodiments, the ball may be formed
do dissolve material (operable to dissolve over time (for
e.g., approximately 1-5 days) under exposure to elevated
temperature (for e.g., approximately 150-250
degrees Fahrenheit) and either brine (for example KCL brine)
or acid (for example approximately 2-5 pH range). One ex-
ample of such a material might be TervAlloy dissolvable
metallic material or similar materials sold by Terves, Inc.
Another example of such material might be dissolvable poly-
meric material by Bubblightt L.L.C. C. In some embodi-
ments, the plug seat (or at least portions of the plug seat, such
as the one or more wedge rings and/or the seal ring) would be
formed of dissolvable material (for example, operable to dis-
solve over time (for example, approximately 1-5 days) under
exposure to elevated temperature (for example a range of
approximately 150-250 degrees Fahrenheit) and either brine
(for example KCL brine) or acid (for example approximately
2-5 pH range). Again, exemplary materials might be TervAl-
loy or similar materials sold by Terves, Inc., or dissolvable
polymeric material by Bubblightt L.L.C. So, the slip ring
and/or one or more wedge rings may be formed of the same
do dissolve material as the ball (or in some embodiments, the
wedge ring(s) and/or slip ring may be dissolve, while the
ball might not be).

Once the plug seat has been sealed (isolating the down-
stream portion of the well), the method might include fruc-
turing a zone of the well above the set and sealed plug seat
(e.g., with the ball in place on the upper wedge ring). In most
instances, the wellbore in question would comprise a hori-
zontal portion (e.g., a horizontal well), having a toe and a heel.
Typically, the initial plug seat is set towards the toe of the hori-
zontal portion of the well (e.g., farthest downhole). The
process (for example, setting a plug seat, perforating the
casing, sealing the plug seat with a dissolvable ball/plug, and
fracturing the zone) typically would be repeated one or more
times from the toe of the horizontal portion of the well
towards the heel. Then, the ball and/or plug seat would dis-
solve (over about 1-5 days, due to exposure to well conditions
(e.g., elevated temperature, acid and/or brine), without the
need for drilling to open the wellbore). In other words, the
wellbore might be accessed downstream of the location of the
plug seat(s) via tubing and/or wireline without drilling the
ball and/or plug seat (due to the dissolveable nature of the ball
and/or plug seat), allowing production of the well without
drilling the ball and/or plug seat.

FGS. 4A-D illustrate such an exemplary method. In
FIG. 4A, a plug seat 410 is pumped to the desired depth on a
wireline, and is set in place using a setting tool. Typically, this
initial plug seat 410 would be set in place towards the toe 401
of the horizontal well 402. And typically, the plug seat 410
would be set in place by application of longitudinal force
upon the wedge ring(s) of the plug seat 410, thereby drive-
ning the slip ring of the plug seat 410 radially outward and into
contact with the casing/wellbore 405. Once the plug seat has
been set, the well zone would be perforated above the set plug
seat (as shown in FIG. 4B). Oftentimes, a single tool string
would be made-up having the plug seat 410, a setting tool (not
shown), and a perforating gun (not shown). This would allow
the plug seat 410 to be set and the well zone to be perforated
in a single trip downhole.

Once the well has been perforated (and the tool
string, for example having the setting tool and or perforat-
ing gun, has been removed), a dissolvable ball 450 might be
dropped and pumped downhole until it is seated on the plug
seat 410 (as shown in FIG. 4B). Once the well has been
sealed, fracturing operations may be performed in the desired
zone above the plug seat 410 (as shown in FIG. 4B). This
process may be repeated until all desired zones have been
fractured (e.g. placing multiple plug seats, typically proceed-
ing from the toe 401 towards the heel 402 of the horizontal
well). FIG. 4C shows an exemplary well, in which a plurality
of plug seats have been set in place and sealed (via dissolve-
able ball), and fracturing operations have occurred in a zone
above each of the plug seats. In such an exemplary method, there
would be no need to drill out the plugs (after all fracturing
operations have been completed). Rather, the plugs (e.g. the
ball/plug and/or wedge ring(s)) would disappear after a pre-
determined period of time (dissolving under well conditions,
as shown for example in FIG. 4D). In the embodiment of FIG.
4D, the ball and wedge ring(s) would be formed of dissolve-
ble material, such that after the predetermined period of
time, only the slip ring (and any elastomeric seal on the slip
ring) of each plug seat would remain in place in the well
(although in other embodiments, only the ball might be dis-
solvable). In such instances, the inner diameter of the set slip
ring would be sufficiently large that it would not interfere with
production of the well (for example, allowing passage of
tubing and/or wireline devices). In other embodiments, how-
ever, the slip ring (as well as the ball and wedge ring(s)) might
be formed of dissolvable material (for example, to provide an
even larger longitudinal bore). Once the dissolvable elements
have disappeared, the operator may proceed with well start-
up and production activities.

While various embodiments in accordance with the
principles disclosed herein have been shown and described
above, modifications thereof may be made by one skilled in
the art without departing from the spirit and the teachings of
the disclosure. The embodiments described herein are rep-
resentative only and are not intended to be limiting. Many
variations, combinations, and modifications are possible and
are within the scope of the disclosure. Alternative embodi-
ments that result from combining, integrating, and/or omit-
ting features of the embodiment(s) are also within the scope
of the disclosure. And logic flows for methods do not neces-
sarily require the particular order shown, or sequential order,
to achieve desirable results. Other steps may be provided, or
steps may be eliminated, from the described flows/methods,
and other components may be added to, or removed from, the
described devices/systems. So, other embodiments may be
within the scope of the following claims.

Accordingly, the scope of protection is not limited by
the description set out above, but is defined by the claims
which follow, that scope including all equivalents of the sub-
ject matter of the claims. In the claims, any designation of a
claim as depending from a range of claims (for example H-##)
would indicate that the claim is a multiple dependent claim
based of any claim in the range (e.g. dependent on claim # or
claim ## or any claim therebetween). Each and every claim is
incorporated as further disclosure into the specification and
the claims are embodiment(s) of the present invention(s).
Furthermore, any advantages and features described above
can relate to specific embodiments, but shall not limit the
application of such issued claims to processes and structures.
accomplishing any or all of the above advantages or having any or all of the above features.

Additionally, the section headings used herein are provided for consistency with the suggestions under 37 C.F.R. 1.77 or to otherwise provide organizational cues. These headings shall not limit or characterize the invention(s) set out in any claims that may issue from this disclosure. Specifically and by way of example, although the headings might refer to a “Field,” the claims should not be limited by the language chosen under this heading to describe the so-called field. Further, a description of a technology in the “Background” is not to be construed as an admission that certain technology is prior art to any invention(s) in this disclosure. Neither is the “Summary” to be considered as a limiting characterization of the invention(s) set forth in issued claims. Furthermore, any reference in this disclosure to “invention” in the singular should not be used to argue that there is only a single point of novelty in this disclosure. Multiple inventions may be set forth according to the limitations of the multiple claims issuing from this disclosure, and such claims accordingly define the invention(s), and their equivalents, that are protected thereby. In all instances, the scope of the claims shall be considered on their own merits in light of this disclosure, but should not be constrained by the headings set forth herein.

Use of broader terms such as comprises, includes, and having should be understood to provide support for narrower terms such as consisting of, consisting essentially of, and comprised substantially of. Use of the term “optionally,” “may,” “might,” “possibly,” and the like with respect to any element of an embodiment means that the element is not required, or alternatively, the element is required, both alternatives being within the scope of the embodiment(s). Also, references to examples are merely provided for illustrative purposes, and are not intended to be exclusive.

Also, techniques, systems, subsystems, and methods described and illustrated in the various embodiments as discrete or separate may be combined or integrated with other systems, modules, techniques, or methods without departing from the scope of the present disclosure. Other items shown or discussed as directly coupled or communicating with each other may be indirectly coupled or communicating through some interface, device, or intermediate component, whether electrically, mechanically, or otherwise. Other examples of changes, substitutions, and alterations are ascertainable by one skilled in the art and could be made without departing from the spirit and scope disclosed herein.

What is claimed is:

1. An expandable plug seat device operable to be set within casing for a wellbore, comprising:
   an expandable slip ring, wherein the expandable slip ring is configured to expand by deforming radially outward; and
   one or more wedge rings configured to slide longitudinally upon application of sufficient longitudinal force and located with respect to the slip ring so that application of sufficient longitudinal force on the one or more wedge rings operates to drive the slip ring radially outward;
   wherein:
   the one or more wedge rings each comprise a wedge-like shape;
   the expandable plug seat has an unset configuration and a set configuration; in the unset configuration, the slip ring has an initial outer diameter that is less than the inner diameter of the casing; and
   in the set configuration, the outer diameter of the slip ring is configured to contact the inner diameter of the casing with sufficient force to hold the slip ring in place during subsequent operations.

2. The device of claim 1, wherein the one or more wedge rings each comprise a vertex having an angle ranging from about 30-20 degrees.

3. The device of claim 1, wherein the expandable slip ring comprises an external elastomeric seal.

4. The device of claim 1, wherein the slip ring is configured to expand by plastic deformation radially outward into contact with the casing of the wellbore; and wherein, in the set configuration, the outer diameter of the slip ring contacts the inner diameter of the casing with sufficient force to form a seal therebetween.

5. The device of claim 1, wherein the slip ring is configured to expand by elastic deformation radially outward into contact with the casing of the wellbore; and wherein, in the set configuration, the outer diameter of the slip ring contacts the inner diameter of the casing with sufficient force to form a seal therebetween.

6. The device of claim 1, wherein the slip ring comprises an outer surface, and the outer surface comprises a plurality of anchoring teeth for securely attaching the slip ring in place on the inner surface of the casing.

7. The device of claim 1, wherein the slip ring comprises an outer surface and a plurality of slots extending longitudinally and located radially around a circumference of the outer surface of the slip ring.

8. The device of claim 1, wherein the device consists essentially of only the slip ring and the one or more wedge rings.

9. The device of claim 1, wherein the one or more wedge rings are formed of dissolvable material.

10. The device of claim 1, wherein the slip ring is formed of dissolvable material.

11. The device of claim 9, wherein the slip ring is formed of dissolvable material.

12. The device of claim 1, further comprising a ball configured to seat on the one or more wedge rings and formed of dissolvable material.

13. The device of claim 1, wherein the device is configured to be made-up into a tool string with a wireline-conveyed power charge setting tool.

14. The device of claim 1, further comprising a mandrel and a lock ring, and wherein the mandrel comprises a ball seat and an angled outer surface portion located and oriented to work in conjunction with the wedge ring to drive the slip ring radially outward from the unset position to the set position when sufficient longitudinal force is applied to the wedge ring.

15. The device of claim 1, wherein the one or more wedge rings comprise two wedge rings; and wherein, in the unset configuration, one wedge ring is located below the slip ring and one wedge ring is located above the slip ring.

16. The device of claim 1, wherein the one or more wedge rings comprise a single wedge ring; and wherein, in the unset configuration, the wedge ring is located above the slip ring.

17. A method of performing downhole operations within a cased wellbore using a plug seat, wherein the plug seat includes a slip ring and one or more wedge rings located with respect to the slip ring so that application of sufficient longi-
tudinal force on the one or more wedge rings operates to drive the slip ring radially outward, the method comprising the steps of:

applying a sufficient longitudinal force onto the one or more wedge rings, thereby deforming the slip ring radially outward into contact with the casing.

18. The method of claim 17, wherein the slip ring deforms plastically upon application of sufficient force via the one or more wedge rings, until the slip ring contacts the casing of the wellbore to securely affix the plug seat to the casing.

19. The method of claim 17, wherein the slip ring deforms elastically upon application of sufficient force via the one or more wedge rings, until the slip ring contacts the casing of the wellbore to securely affix the plug seat to the casing.

20. The method of claim 17, wherein the longitudinal force is applied to the one or more wedge rings by a wireline-conveyed power charge setting tool.

21. The method of claim 17, wherein the one or more wedge rings comprise an upper wedge ring located above the slip ring; the method further comprising landing a dissolvable ball on the upper wedge ring.

22. The method of claim 21, wherein the ball dissolves due to exposure to well conditions over time, thereby opening the wellbore without the need for drilling.

23. The method of claim 17, further comprising making-up a tool string comprising the plug seat, a wireline-conveyed power charge setting tool, and a perforating gun assembly.

24. The method of claim 23, further comprising positioning the plug seat in the wellbore, setting the plug seat using the wireline-conveyed power charge setting tool, and perforating the well casing, all in a single trip downhole.

25. The method of claim 24, wherein the wellbore comprises a horizontal portion, having a toe and a heel; the method further comprising repeatedly setting plug seat, perforating the wellbore, sealing the wellbore by landing ball on the plug seat, and fracturing the wellbore using a plurality of plug seats and balls proceeding from the toe of the horizontal portion of the wellbore towards the heel.
