NON-ORIENTATED TUBING HANGER WITH FULL BORE TREE HEAD

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to and the benefit of co-pending U.S. Provisional Application Ser. No. 61/045,503, filed April 16th, 2008, the full disclosure of which is hereby incorporated by reference herein.

1. Field of Invention

[0001] This invention relates in general to production of oil and gas wells, and in particular to a full bore wellhead assembly.

2. Description of Related Art

[0002] Wellheads used in the production of hydrocarbons extracted from subterranean formations typically comprise a wellhead assembly. Wellhead assemblies are attached at the upper ends of wellbores that intersect hydrocarbon producing formations. Wellhead assemblies also provide support for tubing and casing inserted into the wellbore. The casing lines the wellbore, thereby isolating the wellbore from the surrounding formation. The tubing typically lies concentric within the casing and provides a conduit for producing the hydrocarbons entrained within the formation.

[0003] Wellhead assemblies also typically include a production tree connecting to the upper end of the wellhead housing. The production tree controls and distributes the fluids produced from the wellbore. Valves assemblies are typically provided within

wellhead production trees for controlling the flow of oil or gas from a wellhead and/or for controlling circulating fluid flow in and out of a wellhead. Gate valves and other sliding stem-type valves have a valve member or disc and operate by selectively moving the stem to insert/remove the valve member into/from the flow of fluid to stop/allow the flow when desired.

SUMMARY OF INVENTION

[0004] A subsea wellhead assembly includes a wellhead housing, a production tree, a tubing hanger adapted to land in the wellhead assembly inside the wellhead housing, a bridging element on the tubing hanger in the production tree, a port radially formed through the tubing hanger, a production port radially through the wellhead housing, and a gallery annulus that circumscribes the bridging element lower portion on one end and circumscribes the tubing hanger on its other end. The gallery annulus is in communication with both the production port and the gallery port so that fluid can be produced from the well through the gallery annulus.

Brief Description of the Drawings:

[0005] Figure 1 is a schematic partial cross sectional view of an embodiment of a full bore wellhead assembly.

Detailed Description of the Invention:

[0006] The present invention will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like numbers refer to like elements throughout. For the convenience in referring to the accompanying figures, directional terms are used for reference and illustration only. For example, the directional terms such as "upper", "lower", "above", "below", and the like are being used to illustrate a relational location.

[0007] It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments of the invention and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

[0008] FIG. 1 provides a side partial cross-sectional view of an embodiment of a wellhead assembly 10 in accordance with the present disclosure. The wellhead assembly 10 can be used with a subsea well for controlling production fluid from within a hydrocarbon producing wellbore. An outer wellhead housing 12 is at the upper end of

an annular conductor pipe 14 extending into the wellbore. Coaxially disposed within the outer wellhead housing 12 is a high pressure/ inner wellhead housing 16. A production tree 34 attaches to the upper end of the high pressure wellbore housing 16. A tubing hanger 18 is shown coaxially within the high pressure wellhead housing 16 and affixed to the wellhead housing 16 by a tubing hanger latch or locking member 20. An elastomeric seal 38 is shown positioned in a region between the outer circumference of the tubing hanger 18 and inner surface of the high pressure housing 16. Seal 38 is located below and in contact with a downward facing shoulder 43 on tubing hanger 18. An energizing ring 36 for engaging the locking element 20 is shown located below seal 38; the energizing ring 36 has a tapered lower end. When landing tubing hanger 18, outward-biased locking member 20 will snap into its profile in wellhead housing 18. Continued downward movement of tubing hanger 18 causes shoulder 43 to push downward on seal 38, which in turn pushes downward on energizing ring 36 to wedge locking member 20 in the locked position. This movement also energizes seal 38. The downward movement of tubing hanger 18 is in response to the weight of the running string for tubing hanger 18 and the weight of the string of tubing 24.

[0009] The tubing hanger 18 outer diameter transitions inward above the seal 38, defining a housing annulus 21 between the tubing hanger 18 and the high pressure housing 16 inner radius. Tubing hanger 18 has an axial production flow passage 17 extending through it. A production port 19 extends through the sidewall of tubing hanger 18 near an upper end of tubing hanger 18, communicating axial flow passage 17

with housing annulus 21. The upper end of tubing hanger 18 is flush or slightly below the upper end of high pressure wellhead housing 16.

[0010] A casing hanger 22 is shown latched to the high pressure housing 16 inner diameter; the casing hanger 22 radially circumscribes a lower portion of the tubing hanger 18. Casing hanger 22 is attached to the upper end of a string of casing 25 that is cemented in the well. Casing hanger 22 is sealed to the inner diameter of high pressure wellhead housing 16 by a seal or packoff (not shown). A pressure seal 32 is shown disposed in the annular region between the tubing hanger 18 and the casing hanger 22. Production tubing 24 extends downward from tubing hanger 18 into casing 25 for conveying production fluids from the borehole into the wellhead assembly 10. A spacer 41 is shown coaxially atop the casing hanger 22 and below a downward-facing shoulder on tubing hanger 18. A locking element 45, also between the tubing hanger 18 and high pressure housing 16, is located above the housing. Locking element 45 is biased outward for engaging a mating profile in the inner diameter of high pressure wellhead housing 16.

[0011] A tubing annulus 26 between the production tubing 24 outer diameter and casing 25 inner circumference extends downward from tubing hanger 18. A tubing annulus passage 28 is shown axially extending within a sidewall of tubing hanger 18 offset from production passage 17. Tubing annulus passage 28 has a lower end in communication with tubing annulus 26 and an upper end shown terminating at an isolation valve 51 inserted in the passage 28 proximate the tubing hanger 18 upper end. An example of an isolation valve suitable for use herein is found in US patent 7,219,741, which is

incorporated by reference herein in its entirety. Alternatively, (as also shown in Figure 2) the upper portion of tubing annulus passage 28 angles radially outward into communication with a tubing annulus gallery or chamber 29 that circumscribes the tubing hanger 18. Tubing hanger 18 may include more than one tubing annulus passage 28 formed therethrough. A tubing annulus port 30 is illustrated in dashed outline and formed for fluid communication with the tubing annulus gallery 29 and thus the tubing annulus passage 28. The port 30, tubing annulus gallery 29, and passage 28 provide fluid and pressure communication between a workover line (not shown) and the tubing annulus 26. Optionally, a selectively opened and closed valve (not shown) can be in the port 30 and in communication with a control line ported to the tree 34 external to the housing 16.

[0012] The production tree 34 is attached to the wellhead at the upper end of the high pressure housing 16. A connector assembly 40 extends downward from the outer circumference of the tree 34 for attaching the production tree 34 to the remainder of the wellhead. The assembly 40 includes a hydraulically actuated cam 44 and dogs 42, wherein the dogs 42 are profiled to match corresponding profiles on the outer diameter of the high pressure housing 16.

[0013] An axial bore 37 is formed through the tree 34 in which a bridge member 46 is coaxially inserted. Axial bore 37 has a diameter that is the same or larger than the minimum inner diameter of the bore of high pressure wellhead housing 16. The bridge member 46 has a larger diameter upper portion and a smaller diameter lower portion, defining a shoulder or transition 47. A tree annulus 35 is formed between the bridge

member 46 and the inner diameter of the tree bore 37 below the transition 47. In the embodiment shown, the bridge member 46 lower end is landed on the upper terminal end of the tubing hanger 18 and the bridge member 46 upper end terminates at about the upper terminal end of the tree 34. The engagement between bridge member 46 and tubing hanger 18 is shown schematically. As an alternative to a bypass registering with the port 30, an upper bypass passage 55 is shown bored axially through the bridge member 46 sidewall and into the tree cap 37. The upper bypass passage 55 lower end registers with the tubing annulus passage 28 and receives therein a portion of the isolation valve 51.

[0014] A portion of bridge member 46 would stab into or over a portion of tubing hanger 18 so as to form a seal between tubing hanger production passage 17 and an axial passage 49 extending through bridge member 46. The upper end of bridge member 46 is shown flush with the upper end of tree 34. A flowline 58 connects to the tree 34 outer housing adjacent a production port 59 formed through a sidewall of tree 34 housing. The production port 59 communicates with the tree annulus 35 thus providing fluid communication from the production flowline 58 and the tree annulus 35. A wing valve 60 is shown in phantom that is inline with the flowline 58.

[0015] One or more seals 48 are provided between bridge member 46 and bore 37 inner diameter. A lock or latch mechanism 50 anchors the bridge member 46 within the body of the production tree 34. In one embodiment, the latch mechanism 50 includes a split ring compressed into a groove circumscribing the bridge member 46. The axial passage 49 in bridge member 46 and the axial passage 17 in casing hanger 18 annulus are

coaxially aligned. A tree cap 54 overlays the upper portion of the production tree 34 having a bore defining the passage 49 upper end. A master valve 52 is located within bridge member 46, and a swab valve 56 is shown in a passage in tree cap 54 line with the passage 49. Valves 52 and 56 can be gate valves, ball valves, or any valve or member able to control flow.

[0016] Gallery passage 19 enables fluid communication between axial production passage 17 in tubing hanger 18 and housing annulus 21. The housing annulus 21 is open to the tree annulus 35, thereby providing fluid communication from within the axial production passage 17 in tubing hanger 18 to the production flowline 58. One of the advantages of the device described herein is that no orientation is required for installing the tubing hanger 18 within the wellhead assembly 10. Additionally, the assembly shown in FIG. 1 provides a full bore access through the wellhead assembly that may accommodate drilling through tree 34. Fluid flow from within the tubing hanger 18 up to the production flowline 58 is illustrated by the arrow A.

[0017] In one mode of operation, the outer wellhead housing 12 with the associated conductor pipe 14 may be installed in a well. Then, the well is drilled deeper and high pressure wellhead housing 16 and its casing 25 are installed. The operator may then install production tree 34 on the wellhead housing 16 prior to completing the drilling of the well. The operator connects a riser and blowout preventer to tree 34 and drills deeper through tree 34. When at a desired depth, the operator installs casing hanger 22 along with its casing 25 by lowering them through the riser, blowout preventer, and tree 34. If casing 25 is the last string of casing, the operator may run tubing hanger 18,

which locks locking element 20 and sets seal 38 through the weight of the running string and the string of tubing 24. The operator then installs bridge member 46.

[0018] The operator may circulate the drilling mud out of tubing 24 by connecting a tubing annulus line (not shown) to tubing annulus port 30. The operator can pump water, or other liquids, downward through the riser and into tubing 24, which circulates back up tubing annulus passage 26, gallery 29, and out tubing annulus port 30. The operator may perforate casing 25 to complete the well by lowering a perforating gun through bridge member 49, and tubing hanger 18 into tubing 24. After completion, the operator disconnects the riser and installs tree cap 54. During production, master valve 52 and swab valve 56 are closed. Other methods may also be performed, including drilling the well to total depth and installing tubing hanger 18 before installing three 34. If so, a debris cap (not shown) could be placed on the upper end of wellhead housing 16 until tree 34 is installed.

[0019] An alternative wellhead assembly 10 embodiment is illustrated in Figure 2 depicting the radial port 19a in the bridge member 46 and proximate to the production port 59. Providing the radial port 19a in the bridge member 46 rather than the tubing hanger 18 may depend on where the tubing hanger 18 upper end terminates.

[0020] Alternative wellhead housing assemblies 10b, 10c are illustrated in side sectional views in Figures 3 and 4. Referring now to Figure 3, an alternative bridge member 46b is depicted having a circumferential channel 57 provided on its outer radial surface. The bridge member 46b outer surface is shown in sealing contact with the tree bore 37 above and below the channel 57 thereby defining the tree annulus 35b therein.

The tree annulus 35b communicates directly with the production port 59 and with the axial passage 49b through a gallery passage 19b laterally formed through the bridge member 46b. The bridge member 46b of Figure 3 further depicts an upper passage 55 with its lower end registering with the tubing annulus passage 28 and receiving the isolation valve 52. Figure 4 presents a wellhead housing assembly 10c embodiment with an upper passage 55a routed axially through the wellhead housing 16b and housing annulus 21a and then laterally outside of the wellhead assembly 10c through the production tree. In both the configurations provided in Figures 3 and 4, the path of produced fluid, as represented by the arrows, moves axially upward within the passage 49b, 49c, flows into the tree annulus 35b, 35c through the gallery passage 19b, 19c, and then through the production port 59b, 59c.

[0021] The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present invention disclosed herein and the scope of the appended claims.

Claims

What is claimed is:

1. A subsea wellhead assembly comprising:

a wellhead housing having an axial bore;

a production tree secured to the wellhead housing upper end,

a tree bore axially formed in the production tree and coaxially aligned with the housing axial bore;

a tubing hanger landed in the wellhead housing;

an axial passage in the tubing hanger;

an annular bridging member atop the tubing hanger and coaxially disposed in the tree bore;

a production port extending laterally through a sidewall of the production tree above the tubing hanger;

a gallery annulus between the tree bore and a lower portion of the bridging member that registers with the production port and extends between the wellhead housing axial bore and tubing hanger upper end; and

a gallery passage laterally extending from the axial passage in the tubing hanger through a sidewall of the tubing hanger that registers with the gallery annulus, so that landing the tubing hanger in any azimuthal orientation in the wellhead housing

creates communication between the axial passage in the tubing hanger to the production port via the gallery passage and gallery annulus.

2. The subsea wellhead assembly of claim 1, further comprising casing depending downward into a wellbore, tubing within the casing, and a tubing annulus between the tubing and the casing.

3. The subsea wellhead assembly of claim 2, further comprising:

a vent annulus between the tubing hanger and the wellhead housing that is sealed from the gallery annulus;

a tubing annulus passage extending through the tubing hanger between the tubing annulus and the vent annulus; and

a tubing annulus port extending through a sidewall of the wellhead housing and in fluid communication with the vent annulus.

4. The subsea wellhead assembly of claim 1, wherein the gallery passage in the tubing hanger is below the production port in the tree.

5. The subsea wellhead assembly of claim 1, wherein the gallery passage is a single port formed at a single azimuthal location.

6. The subsea wellhead assembly of claim 1, further comprising a tree cap selectively attachable to the production tree upper section.

7. The subsea wellhead assembly of claim 1, further comprising:

a tubing hanger locking member on an exterior portion of the tubing hanger;

a tubing hanger seal on the tubing hanger that sealingly engages the tree bore; and

a downward-facing shoulder on the tubing hanger above the tubing hanger seal and the locking member that sets the seal and the locking member in response to weight.

8. The subsea wellhead assembly of claim 1, further comprising:

an outward-biased tubing hanger locking member on an exterior portion of the tubing hanger;

a mating profile in the axial bore of the wellhead housing that is engaged by the locking member;

an energizing ring above the locking member and having a tapered portion that engages the locking member;

a tubing hanger seal on the tubing hanger having a lower end in engagement with the energizing ring; and

a downward-facing shoulder on the tubing hanger in contact with an upper end of the tubing hanger seal, such that continued downward movement of the tubing hanger after the locking member has engaged the profile causes the shoulder to move

the energizing ring downward to wedge the locking member outward and deform the seal against the bore of the wellhead housing.

9. The subsea wellhead assembly of claim 1, wherein the bore of the tree has a minimum inner diameter that is at least equal to a minimum inner diameter of the bore of the wellhead housing.

10. A subsea wellhead assembly comprising:

a wellhead housing;

a production tree secured to the wellhead housing upper end,

a bore extending axially through the production tree and the wellhead housing;

a tubing hanger landed in the wellhead housing and having a string of tubing depending downward therefrom;

an axial passage in the tubing hanger;

a tubular bridging member atop the tubing hanger and coaxially disposed in the bore and having at least a portion within the tree;

a production port laterally projecting through the production tree above the tubing hanger;

a gallery annulus coaxially provided within the bore around a portion of the bridging member and registering with the production port;

a gallery passage laterally formed from the axial passage through a sidewall of the tubing hanger that registers with the gallery annulus; and

a flow path defined through the tubing, into the tubing hanger, through the gallery passage to the gallery annulus, and into the production port.

11. The subsea wellhead assembly of claim 10, wherein the gallery annulus surrounds a lower portion of the bridging member within the tree and an upper portion of the tubing hanger within the wellhead housing.

12. The subsea wellhead assembly of claim 10, further comprising:

a vent annulus between the tubing hanger and wellhead housing;

a tubing annulus passage extending from a lower portion of the tubing hanger to an exterior portion of the tubing hanger in fluid communication with the vent annulus; and

wherein a lower end of the tubing annulus passage is in fluid communication with a tubing annulus surrounding the string of tubing.

13. The subsea wellhead assembly of claim 12, further comprising a tubing annulus further comprising a tubing annulus port extending through a sidewall of the wellhead housing and in fluid communication with the vent annulus.

14. The subsea wellhead assembly of claim 12, further comprising a seal circumscribing the tubing hanger at a location below the gallery annulus and above

the vent annulus, thereby blocking communication between the gallery annulus and the vent annulus.

15. The subsea wellhead assembly of claim 10, further comprising:

an outward-biased tubing hanger locking member on an exterior portion of the tubing hanger;

a mating profile the wellhead housing that is engaged by the locking member;

an energizing ring above the locking member and having a tapered portion that engages the locking member;

a tubing hanger seal on the tubing hanger having a lower end in engagement with the energizing ring; and

a downward-facing shoulder on the tubing hanger in contact with an upper end of the tubing hanger seal, such that continued downward movement of the tubing hanger after the locking member has engaged the profile causes the shoulder to move the energizing ring downward to wedge the locking member outward and deform the seal against the wellhead housing.

16 A method of assembling a subsea wellhead assembly comprising:

securing an annular wellhead housing on the seafloor;

deploying a production tree having an axial bore on the wellhead housing thereby defining a main bore that extends through the wellhead housing and the production tree;

landing a tubing hanger in the wellhead housing with attached tubing;

providing a gallery port extending laterally through a sidewall of the tubing hanger;

providing a production port extending laterally through a sidewall of the production tree;

disposing an annular bridging element on the tubing hanger and within the production tree; and

providing communication between the gallery port and the production by through a gallery annulus that circumscribes an upper portion of the tubing hanger and a lower portion of the bridging element and is circumscribed by the main bore.

17. The method of claim 16, further comprising setting a locking member on the tubing hanger and a seal on the tubing hanger by the application of weight of a running string and a tubing string..

18. The method of claim 16, wherein landing the tubing hanger comprises lowering the tubing hanger through the production tree bore.

19. The method of claim 16, wherein landing the tubing hanger is performed without orienting the tubing hanger.

20. The method of claim 16, further comprising:

providing a vent annulus between the tubing hanger and the wellhead housing that is sealed from the gallery annulus; and

providing a tubing annulus passage in the tubing hanger having a lower end that communicates with a tubing annulus surrounding the string of tubing and an upper end that communicates with the vent annulus.