RECOVERABLE PRODUCTION MODULE FOR USE WITH A PRODUCTION TREE

BACKGROUND

1. Field of Invention

[0001] The invention relates generally to equipment for controlling the production of wellbore fluid. More specifically, the invention relates to a module removable from a production tree and having passages that register with passages in the production tree.

2. Description of Prior Art

[0002] Wellheads used in the production of hydrocarbons extracted from subterranean formations typically comprise a wellhead assembly attached at the upper end of a wellbore formed into a hydrocarbon producing formation. An annular wellhead housing typically makes up the outermost member where wellhead assemblies connect to a wellbore. A production tree usually connects to the upper end of a wellhead assembly for controlling flow in and out of the wellbore and allowing access into the wellbore. Support hangers are generally included within the wellhead housing for suspending production tubing and casing 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 therein for producing the hydrocarbons entrained within the formation.

[0003] Production trees typically include flow lines that connect with other lines outside of the wellhead assembly for porting fluid produced from the wellbore to a location for processing the fluid. Production trees also usually contain passages that also connect to a line is external to the

production tree. Typically the passages are used for accessing annuli between concentric wellbore tubulars. The passages are also often used to provide a return path for fluid injected within a tubular (e.g. tubing or casing) that exits the bottom end of the tubular and flows up the wellbore in an annulus around the tubular. Generally, valves regulate flow through the lines and passages, which are included inline with the lines and passages. Thus removing the production tree for service or other reasons usually requires a separate step of disconnecting the lines and passages internal to the tree from the lines and passages external to the tree.

SUMMARY OF THE INVENTION

[0004] Disclosed herein is an example of a wellhead assembly having a production module removably mountable on a production tree and a method of wellbore operations. An example embodiment of a wellhead assembly includes a tubular wellhead housing with a tubing hanger landed within, where the lower end of the tubing hanger is attachable to a tubing string. A production module is included having a mounting bore that extends through the production module; a flow passage projects from the mounting bore through the production module. A production tree is included that selectively inserts into the mounting bore, the production tree mounts on an upper end of the wellhead housing. The production tree includes an axial bore that registers with a bore axially through the tubing hanger. A port is included in the production tree that intersects the axial bore and also intersects an outer surface of the production tree. When the production tree inserts into the mounting bore and the production module lands on the production tree, the port registers with the flow passage. A production spool may optionally be included that couples to the production tree, and where the production spool registers with a production line in the production module when the production module is landed on the production tree. In an example, the port is above the upper end of the tubing hanger. Optionally, the port includes a

production port for the flow of production fluid. In an example embodiment, the port has an auxiliary line in communication with an axial passage in the tubing hanger that communicates with an annular space between the tubing hanger and the wellhead housing. In an optional embodiment, the wellhead assembly further includes a selectively removable actuator disposed on the production module for actuating a valve disposed in the production module.

[0005] Also included herein is a method of wellbore operations. In an example embodiment the method includes providing a production module that has an axial mounting bore and a passage that intersects the mounting bore. The production module is positioned on a production tree that mounts on a wellbore and that has a port intersecting an outer surface of the production tree. The method further includes inserting the production tree into the mounting bore to register the passage with the port thereby landing the production module on the production tree. Optionally, the method also includes coupling a production spool having a production stab with the production tree so that the production stab registers with a production flow line formed in the production module when the production module is landed on the production tree. In an alternative, the method further includes producing fluid from a wellbore in communication with the production tree and removing the production module from the production tree. In an example, closing a single valve in the production tree isolates the production module from communication with the wellbore. In an example embodiment, a production spool couples with a well flow jumper and the production spool includes a production stab; where the production spool is supported by being coupled with the production tree, and the production stab registers with a production flow line formed in the production module when the production module is landed on the production tree, so that when the production module is removed from the production tree, the production spool remains coupled with the well flow jumper. Optionally,

the production tree mounts on a wellhead housing in which a tubing hanger is landed. An actuator may be coupled with the production tree that mechanically couples with a valve provided with the production module, the method can further include operating the valve with the actuator. Fluids may optionally be produced from the wellbore through the production module and actuators mounted on the production module can be removed.

[0006] Also disclosed herein is an example embodiment of a wellhead assembly, that in an example embodiment includes a tubular wellhead housing, a tubing hanger landed in the wellhead housing with a lower end attachable to a tubing string, and a production module. The production module includes an axial mounting bore and a flow passage projecting from the mounting bore. A production tree is included that selectively inserts into the mounting bore; the production tree mounts on an upper end of the wellhead housing. An axial bore in the production tree registers with a tubing hanger bore, where the tubing hanger bore is axially formed through the tubing hanger. Also included is a production passage in the production tree extending between the axial bore and an outer surface of the production tree. A production line is provided in the production module with an entrance that selectively couples with the production passage when the production module is landed onto the production tree. A production stab selectively communicates with an exit of the production line fluid, so that when the production module is landed on the production tree, the production passage is in fluid communication with a production fluid jumper that is connectable to an exit of the production stab. An auxiliary passage may optionally be included in the production module. In an example embodiment, the auxiliary passage engages an auxiliary stab when the production module is landed on the production tree for communicating the auxiliary passage with a tubing annulus.

BRIEF DESCRIPTION OF DRAWINGS

[0007] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0008] Figure 1 is a side sectional view of a production module coupled onto a production tree in accordance with the present invention.

[0009] Figure 2 is a side perspective view of an example of engaging the production module and production tree of Figure 1.

[0010] Figure 3 is a side perspective view of an alternate embodiment of the production module and production tree of Figure 1 in accordance with the present invention.

[0011] Figure 4 is a side perspective view of an example of recovering a production module from a subsea production tree in accordance with the present invention.

[0012] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

[0013] The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be 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 its scope to those skilled in the art. Like numbers refer to like elements throughout.

[0014] It is to be further understood that the scope of the present disclosure 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 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 improvements herein described are therefore to be limited only by the scope of the appended claims.

[0015] Shown in Figure 1 is a side sectional view of an example embodiment of a wellhead assembly 20 that includes a wellhead housing 22 with its lower end mounted on a surface 23 above a formation. In the example of Figure 1, the surface 23 may be a sea floor. An annular casing hanger 24 is landed within the wellhead housing 22 and shown having a string of casing 26 connected on its lower end that depends downward into a wellbore. Figure 1 further illustrates a tubing hanger 28 shown landed on an inner surface of the wellhead housing 22 and above the upper end of the casing hanger 24. A tubing string 30 attaches to a lower end of the tubing hanger 28 and projects downward concentrically within the casing hanger 24 and casing 26. An annulus 32 is defined between the tubing 30, wellhead housing 22, casing hanger 24, and casing 26.

[0016] Mounted on an upper end of the wellhead housing 22 is a production tree 34 that is attached to the wellhead housing 22 by a clamp 36. Landed on the production tree 34 is a production module 38 that is shown having a bore 40 axially formed through the production

module 38 and in which the upper end of the production tree 34 is inserted. Within the production module 38 is an auxiliary line 42 shown extending laterally outward from the bore 40 and intersected by another auxiliary line 44. The production module 38 is positioned on the production tree 34 so that auxiliary line 42 registers with a vent line 46 shown formed axially through the production tree 34. A valve 48 within the vent line 46 is provided that may be used for regulating or controlling flow through the vent line 46. Similarly, within the auxiliary lines 42, 44 are valves 50, 52 for controlling flow through the auxiliary lines 42, 44. An axial passage 54 extends through the tubing hanger 28, thereby providing fluid communication from the tubing annulus 32 and into the vent 46. Thus, communication to the tubing annulus 32 may be obtained via the auxiliary lines 42, 44 and selective control of the valves 48, 50, 52.

[0017] Also shown formed through the production nodule 38 and intersecting the bore 40 is a production line 56 that registers with a production port 58 when the production module 38 is landed on the production tree 34. A valve 60 is shown disposed within the production port 58 for controlling flow or communication through the production port 58. A bypass line 62 intersects the production line 56 within the production module 38. Valves 64, 66 respectively provided in the production line 56 and bypass line 62 may be actuated for selectively diverting flow through the production line 56 or bypass line 62. Also provided in the bypass line 62 is a choke 68 that restricts the cross-sectional area in the bypass line 62 for reducing pressure of the fluid flowing through the bypass line 62 into a pressure more manageable for production of fluid from the wellbore.

[0018] Still referring to Figure 1, an annular production stab 70 is shown providing coupling between the tubing hanger 28 and lower end of the production tree 34 for providing seamless flow from within the wellbore and up to the production port 58. The tubing 30, tubing hanger

28, production stab 70, and inner bore of the production tree 34 are substantially coaxial and define a main production bore 71 through the wellhead assembly 20. A production main valve 72 is shown set in the main production bore 71 in the portion within the production tree 34. The production main valve 72 may be selectively opened or closed to regulate communication to the wellbore through the main production bore 71. Proximate the upper end of the production tree 34 is a swab valve 74 also set within the main production bore 71 and that may be opened or closed to allow access to within the main bore 71 from the upper end of the production tree 34.

[0019] An optional sensor 76 is shown coupled on an outer surface of the production module 38 and in communication with the production tree 34. A lateral passage 80 formed through the production module 38 provides a path for the line 78. Similarly, an actuator 82 is shown mounted on the production module 38 and coupled to a control line 84 that is set within a passage 86. The passage 86 enables path for the control line 84 to connect to actuators or devices within the production tree 34 and/or production module 38.

[0020] Referring now to Figure 2, a side perspective view is shown of an example embodiment of landing the production module 38 of Figure 1 onto the production tree 34. In this example, a bridle assembly 88 is coupled onto an upper end of the production module 38 and suspended by a line 90. By lowering the production module 38 and aligning the bore 40 in the production module 38 with the upper end of the production tree 34, the production tree 34 is inserted into the bore 40 as the production module 38 is lowered thereon. As the bore 40 extends through the production module 38, access to the main production bore 71 in the production tree 34 is unimpeded by the production bore 38.

[0021] An alternate embodiment of the wellhead assembly 20A is shown in a side perspective view in Figure 3 wherein the production module 38A is set on the production tree 34. In the example of Figure 3, a production spool stab 92 is shown as part of a production spool 94. The production spool 94 is supported by a coupling 95 attaching the production spool 94 to the production tree 34. Valves 96, 98 are shown disposed within the production spool 98 for selectively controlling flow to lines 100, 102 that attach to the production spool 94. The lines 100, 102 may provide a pathway for fluids produced from the wellbore to production facilities (not shown) that process or refine the produced fluids. In the example of Figure 3, the production line 56A has an exit shown intersecting a lower end of the production module 38A. When the production module 38A is landed on the production tree 34 the production spool stab 92 inserts into the exit of the production line 56A. As such, fluid communication between the production spool 92 and main bore 71 is established via the production port 58 and production flow line 56A through the production spool stab 92.

[0022] Also optionally provided in the example of Figure 3 is an optional choke actuator 104 shown mounted to the production tree via coupling 105. Mechanical linkages 106, 108 extend from the choke actuator 104 to valves 64, 66 for regulating flow through the production flow line 56A and/or bypass line 62 in the production module 38A. Thus, by orienting the production module 38A as it lands on the production tree 34, communication can be established between the production flow line 56A and production spool stab 92, as well as automatic coupling of the choke actuator 104 and mechanical linkages 106, 108 for controlling flow through the production flow line 56A.

[0023] Referring now to Figure 4, in an example of operation the production module 38 is shown being removed from the production tree 34, such as for maintenance or other reasons. An

advantage of the example shown is that the connectivity to the jumper flow lines 100, 102 may be maintained as the module 38 is removed from the production tree 34. In this example, only the production main valve 72 is required to be closed in order to isolate flow from the wellbore for allowing removal of the production module 38. Similar to the production spool 94 is an auxiliary spool 110 mounted to the production tree 34 and having an auxiliary stab 112 for automatic coupling with auxiliary line 42A as the production module 38 is landed onto the production tree 34. Further, in the example of Figure 4, a work boat 114 is used for raising and lowering the line 94 removal and/or landing of the production module 38.

[0024] 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.

PARTS LIST

20 wellhead assembly
22 wellhead housing
23 surface
24 casing hanger
26 casing
28 tubing hanger
30 tubing
32 tubing annulus
34 production tree
36 clamp
38 production module
40 bore
42 auxilliary line
44 auxilliary line
46 vent line
48 valve
50 valve
52 valve
54 passage
56 production line
58 production port
60 production wing valve
62 bypass line
64 valve
66 valve
68 choke
70 production stab
71 main production bore
72 production main valve
74 swab valve
76 sensor
78 line
80 passage
82 actuator
84 control line
86 passage
88 bridle assembly
90 line
92 spool stab
94 production spool
95 coupling
96 valve
98 valve
100 line

CLAIMS

What is claimed is.

1. A wellhead assembly comprising:

a tubular wellhead housing;

a tubing hanger landed in the wellhead housing having a lower end attachable to a tubing string;

a production module comprising a mounting bore extending through the production module and a flow passage projecting from the mounting bore;

a production tree that selectively inserts into the mounting bore and that is mounted on an upper end of the wellhead housing;

an axial bore in the production tree that registers with a tubing hanger bore that is axially formed through the tubing hanger; and

a port in the production tree that intersects the axial bore and an outer surface of the production tree, so that when the production tree is inserted into the mounting bore and the production module is landed on the production tree, the port registers with the flow passage.

2. The wellhead assembly of claim 1, further comprising a production spool coupled to the production tree and a production line in the production module that register when the production module is landed on the production tree.

3. The wellhead assembly of claim 1, wherein the port is above the upper end of the tubing hanger.

4. The wellhead assembly of claim 1, wherein the port comprises a production port for the flow of production fluid.

5. The wellhead assembly of claim 1, wherein the port comprises an auxiliary line in communication with an axial passage in the tubing hanger that communicates with an annular space between the tubing hanger and the wellhead housing.

6. The wellhead assembly of claim 1, further comprising a selectively removable actuator disposed on the production module for actuating a valve disposed in the production module.

7. A method of wellbore operations comprising:

providing a production module comprising a mounting bore extending through the production module and a passage that intersects the mounting bore;

positioning the production module on a production tree that is mounted on a wellbore and that has a port intersecting an outer surface of the production tree; and

inserting the production tree into the mounting bore and registering the passage with the port thereby landing the production module on the production tree.

8. The method of claim 7, wherein a production spool having a production stab is coupled with the production tree and the production stab registers with a production flow line formed in the production module when the production module is landed on the production tree.

9. The method of claim 7, further comprising producing fluid from a wellbore in communication with the production tree and removing the production module from the production tree.

10. The method of claim 9, wherein closing a single valve in the production tree isolates the production module from communication with the wellbore.

11. The method of claim 9, wherein a production spool coupled with a well flow jumper and having a production stab is supported by being coupled with the production tree, and the production stab registers with a production flow line formed in the production module when the production module is landed on the production tree, so that when the production module is removed from the production tree, the production spool remains coupled with the well flow jumper.

12. The method of claim 7, wherein the production tree is mounted on a wellhead housing in which a tubing hanger is landed.

13. The method of claim 7, wherein an actuator is coupled with the production tree and mechanically couples with a valve provided with the production module, the method further comprising operating the valve with the actuator.

14. The method of claim 7, further comprising producing fluids from the wellbore through the production module and removing actuators mounted on the production module.

15. A wellhead assembly comprising:

a tubular wellhead housing;

a tubing hanger landed in the wellhead housing having a lower end attachable to a tubing string;

a production module comprising a mounting bore extending through the production module and a flow passage projecting from the mounting bore;

a production tree that selectively inserts into the mounting bore and that is mounted on an upper end of the wellhead housing;

an axial bore in the production tree that registers with a tubing hanger bore that is axially formed through the tubing hanger;

a production passage in the production tree extending between the axial bore and an outer surface of the production tree;

a production line in the production module having an entrance that selectively couples with the production passage when the production module is landed onto the production tree; and

a production stab in selective communication with an exit of the production line fluid, so that when the production module is landed on the production tree, the production passage is in fluid communication with a production fluid jumper that is connectable to an exit of the production stab.

16. The wellhead assembly of claim 15, further comprising an auxiliary passage in the production module.

17. The wellhead assembly of claim 16, wherein the auxiliary passage engages an auxiliary stab when the production module is landed on the production tree for communicating the auxiliary passage with a tubing annulus.