A well completion system having a spool tree body defining a vertical bore extending therethrough. The vertical bore defines an annular recess adjacent to the lateral production fluid outlet port in the spool tree body. A tubing hanger is connected to the spool tree body. The tubing hanger defines a vertical bore extending therethrough and has at least a lateral production fluid flow port. The tubing hanger is positioned within the vertical bore such that the lateral production fluid flow port in the tubing hanger is in flow communication with the lateral production fluid outlet port in the spool tree body. There is a removable plug that seals the vertical production bore extending through the tubing hanger above the lateral production fluid outlet port in the spool tree body. A stopper means seals the vertical bore extending through the spool tree body above the removable plug. A workover port extends laterally through the spool tree body and penetrates into the vertical bore above the stopper means. A tubing annulus fluid flow port extends laterally through the spool tree body from beneath the second sealing means from a tubing annulus. The workover port and the tubing annulus fluid flow port are interconnected via an external loop line containing at least one valve.
WELL COMPLETION SYSTEM WITH AN ANNULAR BYPASS AND A SOLID STOPPER MEANS

[0001] This new application is a continuation in part application of pending Ser. No. 09/087,791, filed May 29, 1998 and examined in Group Art Unit 3672 by Examiner W. Neuder. This application is also a continuation in part of Ser. No. 08/909,185 filed Jul. 14, 1997, now abandoned and a continuation of Ser. No. 08/746,212 filed Nov. 6, 1996, now abandoned.

BACKGROUND OF THE INVENTION

[0002] A basic function of a wellhead system is to provide for fluid flow into the well and/or out of the well. The outer end of the required pathway(s) is outside of the outermost well barrier. The inner end of the pathway(s) is either the wellbore or one of the annular spaces between the concentric tubes or tubular bodies.

[0003] Conventionally, wells in oil and gas fields are built up by establishing a wellhead housing, and with a drilling blow out preventer stack (BOP) installed, drilling down to produce the well hole while successively installing concentric casing strings, which are cemented at the lower ends and sealed with mechanical seal assemblies at their upper ends. In order to convert the casing well for production, a tubing string is run in through the BOP and a hanger at its upper end landed in the wellhead. Thereafter, the drilling BOP stack is removed and replaced by a Christmas tree having one or more production bores containing actuated valves and extending vertically to respective laterally production fluid outlet ports in the wall of the Christmas tree.

[0004] This arrangement involves several problems. Any operations down hole have been limited to tooling which can pass through the production bore, which is usually no more than five inches in diameter, unless the Christmas tree is first removed and replaced by a BOP stack. However this involves setting plugs or valves, which may be unrackable by not having been used for a long time, down hole. The well is in a vulnerable condition while the Christmas tree and BOP stack are being exchanged and neither one is in position, which is a lengthy operation. Also, if it is necessary to pull the completion, consisting essentially of the tubing string on its hanger, the Christmas tree must first be removed and replaced by a BOP stack. This usually involves plugging and/or killing the well.

[0005] An existing subsea well completion system commonly called a spool tree, or horizontal tree, or side valve tree typically comprises a wellhead housing, a spool body and connector which latches and seals to the wellhead housing, the spool body having an inside cylindrical surface defining a vertical bore extending throughout having a least a lateral production fluid outlet port connected to a valve. A tubing hanger which lands, locks and seals inside the spool body. The tubing hanger defines a vertical production bore extending through and has a least a lateral production fluid flow port which can align with the lateral production fluid port in the spool body. The tubing hanger seals to the spool body above and below the lateral production fluid outlet. The tubing hanger suspends the weight of production tubing which extends to the bottom of the well for purposes of transporting well fluids back to the well completion equipment.

[0006] A removable plug, commonly operated by wireline means, seals the vertical production bore extending through the tubing hanger above the lateral production fluid outlet. A removable stopper means, commonly referred to as a tree cap, seals the vertical bore through the spool tree body above the tubing hanger. Such a removable stopper may include internal provisions for a removable wireline plug which would seal a production through bore which would align with the production through bore in the tubing hanger. This facility would provide for wireline access to the production tubular without the need to first recover the tree cap.

[0007] A work over port, typically 1.5 to 2 inches in diameter, extends laterally through the spool body and penetrates into the spool vertical bore below the tree cap spool bore seals and above the tubing hanger uppermost spool bore seals.

[0008] A tubing annulus fluid flow port, typically 1.5 to 2 inches in diameter, extends laterally through the spool body and penetrates into the spool vertical bore, commonly referred to as the tubing annulus, below the tubing hanger lowermost spool bore seals.

[0009] The work over port and the tubing annulus fluid flow port are typically interconnected via an external loop line containing at least one valve.

[0010] In one embodiment, the arrangement described for the annulus work over port and the annulus fluid port offers certain advantages. Installation of a tubing hanger and tree cap is accomplished through a BOP stack which latches and seals to the top of the spool body. This provides for additional well control during the installation process.

[0011] The tubing hanger is installed into the wellhead using a specialized running tool commonly referred to as a tubing hanger running tool which includes a vertical tubular member which extends back to the an overhead drilling an installation vessel.

[0012] At some point after installation of the tubing hanger but prior to removal of the tubing hanger running tool, it may become necessary to circulate quickly large volumes of fluid between the main vertical production bore through the tubing hanger and the production tubing annulus surrounding the production tubing.

[0013] The circulation of fluids is as described herein. BOP sealing rams are closed on the tubing hanger running tool extension tubular. Fluid port outlets in the BOP below the sealing rams are interconnected to external tubulars which extend back to the drilling vessel. These external tubulars are commonly referred to as choke or kill lines.

[0014] Communication between the production tubing and the production tubing annulus near the bottom of the well may be accomplished by means of a scalable sliding sleeve which can be opened and closed exposing communication ports between the production tubing and the production tubing annulus. Alternatively, other specialized devices can be used to create communication holes between the tubing and annulus.

[0015] Circulation is finally accomplished by pumping fluids down the production tubing through the lowermost production tubing sliding sleeve, back up the production tubing annulus, into the spool body annulus fluid flow port, through interconnecting external annulus piping, through the
annulus work over port back into the annulus formed by the spool body inside surface and BOP inside surface above the tubing hanger, into the BOP choke/kill lines, and finally back to the surface. Likewise, this process can be performed in reverse by pumping down the choke/kill lines and taking returns through the vertical production tubular.

[0016] This arrangement for circulating fluids into the production tubing annulus is considered advantageous in that it provides for circulation of fluids around the sealed tubing hanger and eliminates the need to have a dedicated bore through the tubing hanger body expressly for this purpose. This however, can only be done prior to installation of the tree cap. After the tree cap has been installed above the tubing hanger, the capability to circulate the production tubing and the production tubing annulus as described above through the BOP is eliminated as the work over port has been sealed off above by the tree cap to the spool tree body bore sealing means.

[0017] As described above, a removable wireline plug may be installed in the tree cap. The purpose of this wireline plug is to allow access to the primary production bore for purpose of performing certain wireline operations in the production tubular downhill. This may be accomplished with a BOP stack installed on the wellhead or by means of a lightweight work over BOP stack or subsea lubricator installed on top of the spool body. In either case, access to the annulus for purposes of circulating the production tubing and production tubing annulus from the overhead work over vessel is eliminated as described above. Annulus circulation can only be achieved by first removing the tree cap to allow access to the annulus work over port in the spool body.

[0018] The object of this invention to provide an improved means to allow access to the production tubing annulus for purposes of circulation as described above with the tree cap installed above the tubing hanger. This is accomplished by routing the lateral work over annulus port into the bore of the spool body above the tree cap to spool body bore sealing means yet below the uppermost BOP stack to spool body uppermost sealing surface.

[0019] With this arrangement, access to the annulus for purposes of circulation is provided at all times, with or without the tree cap installed. Therefore, annulus circulation can be provided through a conventional BOP stack or through a work over BOP or a subsea lubricator system without the need to first remove the tree cap.

[0020] Existing designs assume there will be no need to access the annulus for purposes of circulation when strictly preforming wireline operations. However, this does not account for certain coil tubing operations which may require circulation capabilities in certain scenarios.

OBJECTS OF THE INVENTION

[0021] It is an object of the present invention to provide a well completion system that has an annular bypass port around the tubing hanger and the tree cap.

[0022] It is a further object of the present invention to provide a well completion system that can be used to circulate fluids while the tree cap is in place.

[0023] It is yet another object of the present invention to provide a well completion system that can be used with a solid tree cap assembly.

[0024] Another object of this invention to provide an improved means to allow access to the production tubing annulus for purposes of circulation with the tree cap installed above the tubing hanger.

SUMMARY OF THE INVENTION

[0025] In accordance with the present invention, a well completion system comprises a wellhead housing, a spool tree body fixed and sealed to the housing, and having at least a lateral production fluid outlet port connected to an activated valve, and a tubing hanger landed within the spool tree body at which a lateral production fluid outlet port in the tubing hanger is in flow communication with that in the spool tree body.

[0026] With this arrangement, the spool tree body, takes the place of a conventional Christmas tree but differs therefrom in having a comparatively large vertical through bore without any internal valves and at least large enough to accommodate the tubing completion. The advantages which are derived from the use of such spool tree are remarkable, in respect to safety and operational benefits.

[0027] Thus, in workover situations the completion, consisting essentially of the tubing string, can be pulled through a BOP stack, without disturbing the spool tree body and hence the pressure integrity of the well, whereafter fill production casing drift access is provided to the well through the large bore in the spool tree body. The BOP can be any appropriate workover BOP or drilling BOP of opportunity and does not have to be one specially set up for that well.

[0028] The present invention provides for a well completion system. The system comprises a spool tree body with an inside surface that defines a vertical bore extending therethrough and has at least a lateral production fluid flow port connected to a valve. A tubing hanger lands in, latches to and seals to the spool tree body. The tubing hanger defines a vertical production bore extending therethrough and has at least a lateral production fluid flow port. The tubing hanger is positioned within the vertical bore such that the lateral production fluid flow port in the tubing hanger is in flow communication with the lateral production fluid outlet port in the spool tree body.

[0029] A removable plug seals the vertical production bore extending through the tubing hanger above the lateral production fluid outlet port in the spool tree body. A stopper means seals the vertical bore extending through the spool tree body above the removable plug.

[0030] The tubing hanger is sealed to the vertical bore above the lateral production fluid outlet by a first sealing means and below the lateral production fluid outlet port by a second sealing means.

[0031] A workover port extends laterally through the spool tree body and penetrates into the vertical bore above the stopper means. This allows for fluid to be injected down the production bore and flow back out of the annular space through the tubing annulus fluid flow port through the workover port to an opening in the spool tree body above the tree cap. Using this system allows operations to be carried out while fluid is flowing through the annular spaces. This arrangement also allows for the use of a solid tree cap when this is desirable for safety or stability purposes.
A tubing annulus fluid flow port extends laterally through the spool tree body from beneath the second sealing means from a production tubing annulus. The production tubing annulus is defined by a wellhead casing having an inner diameter and a production tubular having an outer diameter.

The workover port and the tubing annulus fluid flow port are interconnected via an external loop line containing at least one valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of the well completion system.

DETAILED DESCRIPTION

In FIG. 1, a well completion system 10 is shown that can be used in a variety of subsea drilling operations. The system 10 comprises a spool tree body 20 with an inside surface 22 that defines a vertical bore 30 extending therethrough and has at least a lateral production fluid outlet port 40 connected to a valve 50. A tubing hanger 60 is connected to the spool tree body 20. The tubing hanger 60 includes a vertical production bore 70 extending therethrough and has at least a lateral production fluid flow port 80. The tubing hanger 60 is positioned within the vertical bore 30 such that the lateral production fluid flow port 80 in the tubing hanger 60 is in flow communication with the lateral production fluid outlet port 40 in the spool tree body 20. Preferably, the spool tree body 20 is fixed and sealed to a wellhead housing 230.

A removable plug 90 seals the vertical production bore 70 extending through the tubing hanger 60 above the lateral production fluid outlet port 40 in the spool tree body. A removable stopper means 100 seals the vertical bore 30 extending through the spool tree body 20 above the removable plug 90. The removable plug 90 can be a wireline plug and the stopper means 100 can be a solid plug. The solid plug may contain at least one opening closed by a wireline plug.

The tubing hanger 60 is sealed to the vertical bore 30 above the lateral production fluid outlet port 40 by a first scaling means 110 and below the lateral production fluid outlet port 40 by a second scaling means 120.

A workover port 130 extends laterally through the spool tree body 20 and penetrates into the vertical bore 30 above the stopper means 100. In a preferred embodiment, the workover port 130 can be connected to the external loop line 160 by a bypass bore 220 extending generally longitudinally through the spool tree body 20.

A tubing annulus fluid flow port 140 extends laterally through the spool tree body 20 from beneath the second sealing means from a production tubing annulus 150. The production tubing annulus 150 is defined by a wellhead casing tubular 222 having an inner diameter and a production tubular 224 having an outer diameter. The workover port 130 and the tubing annulus fluid flow port 140 are interconnected via an external loop line 160 containing at least one valve 170.

A pressure monitor and bleed port 180 extends laterally through the spool tree body 20 in flow communication with a chamber 190 defined between the first scaling means 110 of the tubing hanger, the removable plug 90 and the stopper means 100. The pressure monitor and bleed port 180 is connected to a valve means 200 and an isolation line 210. The pressure monitor and bleed port 180 is used to monitor the pressure in the tubing annulus and bleed the pressure when the tree cap is being seated on and connected to the tubing hanger. This is a secondary means for monitoring and controlling the pressure in the tubing annulus. The pressure monitor and bleed port 180 defines an inner diameter of about one half inch which prevents its use as a workover port.

We claim:

1. A well completion system comprising:
   a spool tree body having an inside surface defining a vertical bore extending therethrough, and having at least a lateral production fluid outlet port connected to a valve;
   wherein the vertical bore defined by the inside surface of the spool tree body defines an annular recess therein extending circumferentially around the bore and being positioned adjacent to the lateral production fluid outlet port in the spool tree body;
   a tubing hanger defining a vertical production bore extending therethrough and having at least a lateral production fluid flow port, said tubing hanger positioned within the vertical bore at a position at which the lateral production fluid flow port in the tubing hanger is in flow communication with the lateral production fluid outlet port in the spool tree body;
   a removable plug sealing the vertical production bore extending through the tubing hanger above the lateral production fluid outlet port in the spool tree body;
   a stopper means sealing the vertical bore above the removable plug;
   wherein the tubing hanger is sealed to the vertical bore above the lateral production fluid outlet port by a first scaling means and below the lateral production fluid outlet port by a second scaling means;
   a workover port extending laterally through the spool tree body and penetrating into the vertical bore above the stopper means; and
   a tubing annulus fluid flow port extending laterally through the spool tree body from beneath the second scaling means and extending from a production tubing annulus defined by a wellhead casing tubular having an inner diameter and a production tubular having an outer diameter;
   wherein the workover port and the tubing annulus fluid flow port are interconnected via an external loop line containing at least one valve.
2. A system as in claim 1, further comprising a pressure monitor and bleed port having an inner diameter of about one half inch, said pressure monitor and bleed port extending laterally through the spool tree body in flow communication with a chamber defined between the tubing hanger first sealing means the removable plug and the stopper means, said pressure monitor and bleed port being connected to a valve means and monitor/bleed line.
3. A system as in claim 2, wherein the pressure monitor and bleed port defines an inner diameter of about one half inch.

4. A system as in claim 1, wherein the workover port comprises a bypass bore extending generally longitudinally through the spool tree body from the workover port to the external loop line.

5. A system as in claim 1, wherein the removable plug is a wireline plug and the stopper means is a solid plug.

6. A system as in claim 5, wherein the solid plug contains at least one opening closed by a wireline plug.

7. A system as in claim 1, wherein the spool tree body is fixed and sealed to a wellhead housing.

8. A wellhead as in claim 1, wherein the lateral production fluid outlet port in the tubing hanger is up to 180 degrees out of alignment with the corresponding lateral production fluid outlet port in the spool tree body.

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