INTEGRATED FLOW CONTROL DEVICE AND ISOLATION ELEMENT

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ABSTRACT

An apparatus for use in a well includes a mandrel, a flow control device provided on the mandrel, and an isolation element provided on the mandrel to provide isolation between zones of the well.
INTEGRATED FLOW CONTROL DEVICE AND ISOLATION ELEMENT

TECHNICAL FIELD

[0001] The invention relates to an apparatus having an integrated flow control device and isolation element provided on a mandrel.

BACKGROUND

[0002] As part of completing a well, various components are provided into a wellbore to perform different tasks. Two such components include flow control devices and packers. Flow control devices control flow between various parts of the well, such as between reservoir(s) and a flow conduit (e.g., production tubing, injection tubing, etc.), or between other portions of the well.

[0003] The flow control device and packer are typically provided as separate components on a tool string. For example, as shown in FIG. 1, a conventional tool string that is deployed in a well 100 includes two sets 102, 104 of equipment. The first set 102 includes a packer 106 and a separate flow control device 108 that are arranged as two separate modules. The two modules are attached to each other, typically using a threaded connection or by some other coupling mechanism. The second set 104 similarly includes a packer 110 and a flow control device 112 provided on separate modules that are attached to each other. Each packer 106, 110 includes a sealing element 114, 116, respectively, that is expandable to engage the inner wall of the wellbore 100 such that different zones of the wellbore 100 are isolated from each other.

[0004] Providing the flow control devices and packers as separate modules adds to the overall complexity and cost of a tool string. Also, because the flow control device and packer are separate components, the overall length of the tool string is increased, particularly when there is a large number of flow control devices and packers provided on a tool string.

SUMMARY

[0005] In general, according to an embodiment, an apparatus for use in a well comprises a mandrel, a flow control device provided on the mandrel, and an isolation element provided on the same mandrel to provide isolation between zones of the well.

[0006] Other or alternative features will become apparent from the following description, from the drawings, and from the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 illustrates a conventional tool string that includes separate flow control devices and packers according to an embodiment.

[0008] FIG. 2 shows a tool string according to an embodiment that includes modules with integrated flow control devices and packers.

[0009] FIG. 3 is a schematic diagram of a module that includes an integrated flow control device and packer.

[0010] FIG. 4 illustrates a different embodiment of a module with integrated dual flow control devices and packer.

[0011] FIG. 5 illustrates a further embodiment of a module with integrated flow control device, packer, and instruments.

[0012] FIG. 6 illustrates yet another embodiment of a module with integrated flow control device and packers.

DETAILED DESCRIPTION

[0013] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those skilled in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments are possible.

[0014] As used here, the terms "above" and "below", "up" and "down", "upper" and "lower", "upwardly" and "downwardly"; and other like terms indicating relative positions above or below a given point or element are used in this description to more clearly describe some embodiments of the invention. However, when applied to equipment and methods for use in wells that are deviated or horizontal, such terms may refer to a left to right or right to left relationship as appropriate.

[0015] FIG. 2 shows a tool string 200 (part of an intelligent completion) according to an embodiment that includes integrated flow control devices and isolation elements. An "isolation element" refers to any element that is used to provide isolation between different portions (e.g., zones) of a well. One example of such an isolation element is a packer. An isolation element typically includes a sealing element that is expandable to engage some downhole structure, such as the inner wall of the wellbore or a casing to provide sealing isolation.

[0016] As depicted in FIG. 2, the tool string 200 is deployed into the wellbore 100, where the tool string has a first module 202 with integrated flow control device 206 and isolation element 208. The module 202 includes a mandrel 210 on which both the isolation element 208 and flow control device 206 are provided. The isolation element 208 includes a sealing element 212 that is expandable to engage an inner wall or casing of the wellbore 100.

[0017] A "mandrel" refers to an integral support structure, such as a housing or other member, on which various components can be supported, including the flow control device and isolation element. The integral mandrel is distinguished from conventional solutions in which a flow control device and packer are typically provided on separate mandrels that are coupled to each other, such as by a threaded connection, or by some other coupling mechanism.

[0018] The other module 204 similarly includes an integrated flow control device 214 and isolation element 216 arranged on a common mandrel 218. The isolation element includes an expandable sealing element 220.

[0019] In FIG. 2, both sealing elements 212 and 220 of respective isolation elements 208 and 216 are in the expanded position such that isolation is provided between different zones 222, 224, and 226. As depicted in FIG. 2, perforations 228 are formed in a formation adjacent the zone 224 to enable communication between zone 224 and the surrounding formation. Similarly, perforations 230 are provided in the formation adjacent zone 222 to enable fluid communication between zone 222 and the surrounding formation.

[0020] FIG. 3 schematically shows components of an integrated module (202, 204) that integrates an isolation element 208, 216 and a flow control device 206, 214. The isolation element 208, 216 includes an actuation mechanism 300, and the flow control device 206, 214 includes a sliding sleeve 302 that is shiftable along a longitudinal direction of the module 210, 218. The sliding sleeve 302 has a first position to block fluid flow through radial ports 304 formed in the mandrel 210, 218, and a second position in which the ports 304 are fully uncovered to provide fluid flow. The sliding sleeve 302 is also shiftable to one or more intermediate incremental positions to provide partially open positions for controlling fluid flow rate through the ports 304. The sliding sleeve 302 is shiftable by an actuating mechanism 306 of the flow control device 206, 214.
[0021] As further depicted in FIG. 3, a common control line 308 is used to control both the isolation element actuating mechanism 300 and flow control device actuating mechanism 306. The control line 308 can extend from an earth surface location into the wellbore, and is connected to a control line portion 310 extending through the mandrel 210, 218. The control line portion 310 in the mandrel 210, 218 is operatively coupled to both the isolation element actuating mechanism 300 and flow control device actuating mechanism 306. In one example, the control line 308 can be a hydraulic control line to activate the actuating mechanisms 300, 306 with hydraulic pressure. The actuating mechanisms 300 and 306 can be set to actuate at different hydraulic pressures, or alternatively, the actuating mechanisms 300, 306 can be responsive to different numbers of cycles of hydraulic pressures. Cycling hydraulic pressure refers to a sequence of an elevated hydraulic pressure and a reduced hydraulic pressure. Plural cycles of hydraulic pressure refers to plural sequences of such elevated and reduced hydraulic pressures. The isolation element actuating mechanism 300 can be actuated in response to a first number of cycles of the hydraulic pressure, while the flow control device actuating mechanism 306 can be actuated in response to a second number of hydraulic pressure cycles.

[0022] In alternative embodiments, the control line 308 can be an electrical control line or a fiber optic control line. In these cases, the actuating mechanisms 300, 306 are provided with the appropriate control circuitry to decode electrical signaling or optical signaling.

[0023] Furthermore, alternative embodiments may employ more than one control line to address and actuate different functions of the integrated module 202. A combination of hydraulic, electrical, or fiber optic control lines may be used to control an integrated module and provide feedback to the surface. Some of these control lines are shared with and may continue to other integrated modules, for example 204, in the wellbore 100 to minimize the number of control lines going to the surface.

[0024] FIG. 4 shows an alternative embodiment of an integrated module 400 that includes an isolation element 208, 216, a flow control device 206, 214, and an instrumentation section 402. The instrumentation section 402 includes one or more instruments, which can be sensors 404 and control devices 406. A sensor 404 is used to measure some downhole condition, such as temperature, pressure, flow rate, density, strain, resistivity, and so forth. A control device 406 is used to provide a control task with respect to some downhole component, such as to activate a downhole tool. The integrated module 400 includes a common mandrel 408 on which the isolation element, flow control device, and instrumentation section are provided.

[0025] FIG. 5 shows another embodiment of an integrated module 500 that has a common mandrel 502. In the module 500, two flow control devices 504 and 506 are provided along with an isolation element 508. The flow control devices 504, 506 and isolation element 508 are all provided on the common mandrel 502. The module 500 provides a dual flow control function integrated with an isolation function.

[0026] FIG. 6 depicts yet another embodiment of a module integrating a plurality of isolation and flow control functions. Module 600 includes an upper 602 and a lower isolation element 604 to define a specific flow interval along the wellbore axis. The flow control device 606 is placed in between and on the same mandrel as the isolation elements 602 and 604.

[0027] An application where some of the FIG. 6 configuration may be of particular interest is where the isolation elements 602 and 604 are made out of self-swelling isolation materials. These materials (e.g., BACEL hard foam or a hydrogel polymer) are designed to swell and form a seal with the casing or well bore wall when exposed to various fluid environments. As such they do not require any control lines to be actuated and are readily added to the outside of a mandrel in several places if needed.

[0028] By integrating multiple functions onto a single mandrel (module), in accordance with some embodiments, more efficient usage of space in a wellbore can be achieved. The integration allows for more compact (shorter) assemblies of components such that shall zonal isolation can be achieved. Also, integration allows for the sharing of a control line for enhanced efficiency. Moreover, misalignment issues of different components in a tool string can be eliminated or reduced, due to integration of multiple components in one module. Other advantages include a lower probability of leaks due to the elimination of threaded or other connections, reduced number of connections and splices for control lines, and quicker deployment at the job site due to pre-integration.

[0029] While the invention has been disclosed with respect to a limited number of embodiments, those skilled in the art, having the benefit of this disclosure, will appreciate numerous modifications and variations therefrom. It is intended that the appended claims cover such modifications and variations as fall within the true spirit and scope of the invention.

1. An apparatus for use in a well, comprising:
   - a mandrel;
   - a flow control device provided on the mandrel; and
   - an isolation element provided on the mandrel to provide isolation between zones of the well.

2. The apparatus of claim 1, wherein the isolation element comprises an expandable sealing element.

3. The apparatus of claim 1, wherein the isolation element comprises a packer.

4. The apparatus of claim 1, further comprising a second mandrel;
   - a second flow control device on the second mandrel; and
   - a second isolation element on the second mandrel to provide isolation between zones of the well.

5. The apparatus of claim 1, further comprising a second flow control device on the mandrel such that the apparatus provides a dual flow control function integrated with an isolation function.

6. The apparatus of claim 1, further comprising a second isolation element on the mandrel such that the apparatus provides a dual isolation function integrated with a flow control function.

7. The apparatus of claim 1, further comprising at least one sensor mounted to the mandrel.

8. The apparatus of claim 7, further comprising at least one control device mounted to the mandrel, the at least one control device to perform a downhole control task.

9. The apparatus of claim 1, further comprising a common control line operatively coupled to both the flow control device and isolation element to operate the flow control device and the isolation element from the common control line.

10. The apparatus of claim 9, wherein the control line comprises a hydraulic control line,
wherein the hydraulic control line enables remote setting or unsetting of the isolation element using hydraulic pressure, and actuation of the flow control device using hydraulic pressure.

11. (canceled)

12. The apparatus of claim 11, wherein the isolation element and flow control device are responsive to different pressures.

13. The apparatus of claim 11, wherein the isolation element and flow control device are responsive to different numbers of pressure cycles.

14. The apparatus of claim 9, wherein the control line comprises one of an electrical line and fiber optic line.

15. The apparatus of claim 9, further comprising at least another control line, wherein the control lines comprise a combination of at least two of hydraulic, electrical, and fiber optic lines.

16. The apparatus of claim 15, wherein the control lines are shred with other integrated modules in the well bore.

17. A method for use in a well, comprising:
   providing a common mandrel;
   mounting a flow control device onto the common mandrel; and
   mounting an isolation element onto the common mandrel, the isolation element to provide isolation of zones of the well.

18. The method of claim 17, further comprising:
   actuating the flow control device to control fluid flow in the well; and
   actuating the isolation element to isolate two zones in the well.

19. The method of claim 18, wherein actuating the flow control device and actuating the isolation element is performed using a common control line.

20. (canceled)

21. The method of claim 17, wherein mounting the isolation element onto the common mandrel comprises mounting a packer onto the common mandrel.

22. The method of claim 17, further comprising mounting an instrumentation section onto the common mandrel, wherein the instrumentation section comprises mounting the instrumentation section that comprises at least one sensor.

23. (canceled)

24. The method of claim 22, wherein mounting the instrumentation section comprises mounting the instrumentation section that comprises at least one sensor and control device.

25. A system for use in a well, comprising:
   a tool string having a first mandrel, a first flow control device provided on the first mandrel, and a first isolation element provided on the first mandrel to provide isolation between zones of the well.

26. The system of claim 25, wherein the first isolation element comprises a packer.

27. The system of claim 25, wherein the tool string further comprises a second mandrel, a second flow control device provided on the second mandrel, and a second isolation element provided on the second mandrel to provide isolation between zones of the well.

28. The system of claim 25, wherein the tool string further comprises an instrumentation section provided on the first mandrel,
   wherein the instrumentation section comprises at least one sensor and control device.

29. (canceled)

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