DOWNHOLE COMPLETION SYSTEM WITH RETRIEVABLE POWER UNIT

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ABSTRACT

A technique facilitates providing a downhole completion with electrical power. The technique may comprise placing an independent completion in a wellbore section. The independent completion is provided with a removable power unit having a power generator coupled to a power storage device. The technique further comprises communicating data or other signals between the independent completion located in the wellbore section and a second completion located in a separate wellbore section.
DOWNHOLE COMPLETION SYSTEM WITH RETRIEVABLE POWER UNIT

CROSS-REFERENCE TO RELATED APPLICATION

The present document is based on and claims priority to U.S. Provisional Application Ser. No.: 61/385,229, filed Sep. 22, 2010, incorporated herein by reference.

BACKGROUND

Hydrocarbon fluids, e.g. oil and natural gas, are obtained from a subterranean geologic formation, referred to as a reservoir, by drilling a well that penetrates the hydrocarbon-bearing formation. Once a wellbore is drilled, various forms of well completion components may be installed to control and enhance the efficiency of producing fluids from the reservoir. However, many downhole components, e.g. sensors and electrically actuated valves, require power to function properly.

To provide power downhole, attempts have been made to utilize downhole power generation devices. For example, permanent magnet generators have been combined with turbines and located downhole in a wellbore. However, if constant power generation is required from the generator, the wellbore section containing the power generation device must remain open to provide continuous flow through the turbine. In some applications, the downhole power generation devices have been used to generate power for driving a hydraulic pump which, in turn, hydraulically actuates flow control valves. However, such systems have limited use for powering downhole electrical components. Additionally, retrieval and servicing of existing power generation devices tends to be a complex and time-consuming process.

SUMMARY

In general, the present disclosure provides a technique for supplying a downhole completion with electrical power. According to an embodiment, the technique comprises placing an independent completion in a wellbore section. The independent completion is provided with a removable power unit having a hydraulically driven power generator coupled to a power storage device. The technique further comprises communicating data or other signals between the independent completion located in the wellbore section and a second completion located in a separate wellbore section.

BRIEF DESCRIPTION OF THE DRAWINGS

Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

FIG. 1 is a schematic illustration of a well system deployed in a wellbore and including an independent completion with a removable power unit positioned in a wellbore section and another completion deployed in a different wellbore section, according to an embodiment of the present disclosure;

FIG. 2 is a schematic illustration similar to the illustration in FIG. 1 but showing a plurality of independent completions deployed in lateral wellbores and communicating with a completion deployed in a primary or vertical wellbore section, according to an embodiment of the present disclosure; and

FIG. 3 is an illustration of an example of an independent completion comprising a power unit with a power generator and a power storage device deployed in a wellbore, according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

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

The disclosure herein generally relates to a system and methodology regarding well completion systems and more particularly to well completion systems having a retrievable downhole power generating unit. According to one embodiment, an independent completion is deployed in a wellbore section, such as a lateral wellbore section or other desired wellbore section. The independent completion comprises a removable power unit having a power generator and a power storage coupled to the power generator. The well system also may comprise a telemetry system for communicating data between the independent completion and another completion located in a different wellbore section. By way of example, the telemetry system may comprise a wireless telemetry system, such as an electromagnetic or wireless telemetry system or a pressure pulse telemetry system.

In some embodiments, the independent completion comprises a turbine power generator which provides power for monitoring and controlling well fluid production within a wellbore section. The independent completion may be a fully self-sustained system so that no hard wire is required between the wellbore section, e.g. a lateral wellbore section, and a second completion located in a second wellbore section, e.g. in a motherbore. Communication signals may be passed between the independent completion and the second completion via the wireless telemetry system. Additionally, the communication signals may be relayed between the second completion and a control system located at the surface.

Power generated by the turbine power generator within the wellbore section may be stored in a suitable power storage device. By way of example, the power storage device may comprise one or more batteries, e.g. rechargeable batteries, which directly power electrical devices in the independent completion. For example, the electrical power may be used to power electric flow control valves and/or sensors located within the wellbore section. As the batteries become depleted, further production fluid spins the turbine of the turbine power generator to generate power for recharging batteries, thus increasing the life of the downhole independent completion system. Additionally, the entire power unit comprising the power generator and the power storage device may be removable and retrievable to the surface. The power unit may be coupled to the remainder of the independent completion by a suitable coupling, such as an inductive coupling, to enable retrieval and servicing of the power unit. After servicing, the power unit can be re-deployed and reengaged with the remainder of the independent completion in the wellbore section (e.g. a lateral wellbore section or a portion of a vertical wellbore) for extended use during another service lifetime.
In some embodiments, the independent completion comprises an intelligent completion system which may be deployed in the downhole lateral wellbore section and used to power, for example, electric flow control valves. Within the lateral wellbore section, the independent completion may comprise numerous flow control valves which are used in cooperation with one or more production packers to isolate a plurality of production well zones. The multiple electric flow control valves can be controlled via electric power provided by the power unit of the independent completion. The ability to intelligently control each production well zone along the lateral wellbore section can substantially enhance hydrocarbon recovery. In some applications, the wireless telemetry system is used to eliminate the challenges associated with routing a cable through a lateral window and with forming cable connections downhole. In other applications, however, the independent completion may be used in a non-lateral, e.g., vertical, wellbore. For example, downhole power generation can be used for re-completing vertical wells which have no existing electrical feed through the wellhead. Downhole power generation combined with a wireless telemetry system enables monitoring and control without incurring the cost and inconvenience of replacing the wellhead and tubing hanger.

Referring generally to FIG. 1, an embodiment of a well system 20 is illustrated as deployed in a well 22 having a wellbore section 24 and at least one additional wellbore section 26, such as a generally vertical wellbore section. Depending on the application, wellbore section 24 may be a lateral wellbore section or a vertical wellbore section. In the example illustrated, the wellbore section 26 is a generally vertical wellbore section which may comprise a motherbore from which one or more lateral wellbore sections 24 extend. In this embodiment, a well completion 28 is deployed in the wellbore section 26, and an independent completion 30 is deployed in the wellbore section 24, e.g., in a lateral wellbore section. In at least some applications, the independent completion 30 is a fully self-sustained system with no hard wire connection to the well completion 28.

The well completion 28 may comprise a variety of components and systems 32 to facilitate, for example, production and/or injection of fluids. One or more packers 34 may be employed to segregate well zones 36 along wellbore section 26. Similarly, independent completion 30 may comprise a variety of components and systems to facilitate the flow of production fluid and/or injection fluids with respect to one or more well zones 38 located along lateral wellbore section 24.

In the embodiment illustrated, independent completion 30 comprises at least one tubing or housing section 40 and one or more packers 42 surrounding tubing section 40 to isolate the desired well zone(s) 38 along lateral wellbore section 24. The independent completion 30 also comprises a power unit 44 which is removably engaged with the remainder of independent completion 30, e.g., with tubing section 40. By way of example, the power unit 40 comprises a power generator 46 and a power storage device 48 operatively coupled with the power generator 46. By way of further example, the power generator 46 may be a hydraulically driven generator, such as a turbine generator, which is rotated by fluid flow along independent completion 30. For example, the flow of production fluid into lateral wellbore 24 from one or more well zones 38 of the surrounding formation 50 may be used to drive the turbine or other type of hydraulically driven power generator 46.

The resulting electrical power can be used to charge power storage device 48 and/or to directly power a variety of electrical devices 52 positioned in independent completion 30 or at other locations along the lateral wellbore section 24 or at other suitable downhole locations. The power storage device 48 may be in the form of a battery, e.g., a rechargeable battery, which can be charged by the power/current output from power generator 46. This allows the power storage device 48 to provide power for electrical devices 52 even when lateral wellbore section 24 is shut-in or during other periods when no fluid flows through power generator 46.

Electrical devices 52 may comprise a wide variety of electrically powered devices, and the specific types of devices 52 depend on the design of independent completion 30 as well as on operational and/or environmental considerations. The power unit 44 may be used to provide power for a single electrical device 52 or for multiple electrical devices 52. By way of example, electrical devices 52 may comprise one or more flow control valves 54 and one or more sensors 56. The electric flow control valves 54 and the sensors 56 may be placed in the well zones 38 along lateral wellbore section 24. Power may be provided to electrical devices 52 and/or data signals may be output from sensors 56 or other electrical devices 52 through suitable conductors 58. Because the power unit 44 may be selectively engaged and disengaged from the remainder of independent completion 30, a suitable coupling mechanism 60 is employed to enable selective engagement of the power unit 44 while also enabling transfer of signals to or from conductors 58. By way of example, the coupling mechanism 60 may comprise an inductive coupler.

In some applications, no hard wired connections exist between independent completion 30 and well completion 28. In these applications, signals are transferred via a wireless telemetry system 62. The wireless telemetry system 62 may be used to convey control signals from well completion 28 to independent completion 30 and its electrical devices 52. For example, signals may be transmitted downhole from a surface control system 64 to a first transceiver 66 of the wireless telemetry system 62 and those signals are transmitted wirelessly to a second transceiver 68 of wireless telemetry system 62 located on independent completion 30. Similarly, the wireless telemetry system 62 may be used to transmit sensor data and other data wirelessly from independent completion 30 to well completion 28 for relay uphole to surface control system 64. Although the independent completion 30 and wireless telemetry system 62 are amenable to use in lateral wellbores, the wellbore section 24 also may be a vertical wellbore section capable of receiving independent completion 30. In some applications, for example, downhole power generation may be employed in a vertical wellbore and wireless communication can be established through a tubing hanger located below a tree. This approach can be used in, for example, a re-completion in which the existing wellhead and tubing hanger do not have an electrical feed through. The downhole power can be used even though there is no electrical hardware through the existing surface or subsea wellheads.

Referring generally to FIG. 2, another embodiment of well system 20 is illustrated. In this embodiment, the wellbore section 26 is a generally vertical wellbore from which a plurality of the lateral wellbores 24 extend. In each of the illustrated lateral wellbore sections 24, an independent completion 30 is deployed. The independent completions 30 are each fully self-sustained systems which independently
communicate with well completion 28 in vertical wellbore 26 via wireless telemetry system 62. The overall system enables independent flow control and/or other control functions in each lateral wellbore section 24 without requiring connecting equipment or electrical cables between the independent completions 30 and the well completion 28.

[0021] In the embodiment illustrated in FIG. 2, each independent completion 30 comprises removable and retrievable power unit 44. As similarly described with reference to FIG. 1, each power unit 30 comprises the power generator 46 coupled with the corresponding power storage device 48. This enables electrical power to be supplied to electrical devices 52, e.g., flow control valves 54 and sensors 56, via the power generator 46 and/or the power storage device 48. The wireless telemetry system 62 may be designed to independently handle transmission of data signals from each of the independent completions 30 and to transmit control signals to specific independent completions 30 so as to control fluid flow and/or other functions within each lateral wellbore section 24.

[0022] In the embodiments illustrated in FIGS. 1 and 2, the power unit 44 may be retrieved when necessary to recharge the power storage device 48, to service the power unit 44, or to replace the power unit 44 with a new or different power unit. For retrieval, the power unit 44 may be coupled with an appropriate fishing tool or other retrieval tool and pulled to a surface location. For example, the power unit 44 may be sized for retrieval up through an interior of the well completion 28 located in wellbore section 26. The new or serviced power unit 44 is then simply conveyed downhole through the interior of well completion 28 and re-engaged with the remainder of the corresponding independent completion 30 residing in the corresponding wellbore section 24, e.g., a corresponding lateral wellbore section or suitable non-lateral wellbore section.

[0023] Referring generally to FIG. 3, a more detailed example of overall wellbore system 20 and of independent completion 30 is illustrated. However, the independent completion 30, as well as other components and systems of the overall well system 20, may be adjusted with a variety of additional and/or alternate components and systems. The specific components and the arrangement of components and systems depends on the parameters of a given application and environment.

[0024] In the example illustrated, the power unit 44 comprises power generator 46 in the form of a turbine generator 70 and further comprises power storage 48 in the form of a rechargeable battery 72. The power unit 44 also includes coupling mechanism 60 in the form of an inductive coupler 74. Turbine generator 70 and rechargeable battery 72 are electrically coupled to electrical devices 52 via inductive coupler 74. For example, electrical power signals and/or data signals may be transferred through inductive coupler 74 to or from electrical devices, such as electrical flow control valve 54, sensors 56, and a corresponding telemetry unit 76 which is used to transfer signals to or from electrical flow control valve 54 and/or sensors 56 via conductors 58 in cooperation with inductive coupler 74.

[0025] In the embodiment illustrated in FIG. 3, the power unit 44 may be secured within an expanded housing portion 78 via a locking mechanism 80 disposed between power unit 44 and housing portion 78. The electrical flow control valve 54 is powered by power unit 44 and actuated to selectively control the flow of fluid, e.g., production fluid, along lateral wellbore section 24. For example, the electrical flow control valve 54 may be selectively opened to enable flow of well fluid from the surrounding well zone 38 into independent completion 30 through appropriate inlet ports 82. The well fluid then flows through the flow control valve 54 and along an interior of independent completion 30, as represented by arrows 84. The production fluid continues to flow through an interior of the inductive coupler 74 and is released into expanded housing portion 78, as represented by arrows 86.

[0026] Once in expanded housing portion 78, the production fluid flows along an exterior of rechargeable battery 72 within the expanded housing portion 78 until passing through turbine generator 70. The flow of fluid through turbine generator 70 causes rotation of the turbine and generation of electrical power which is supplied to rechargeable battery 72 and/or to electrical devices 52 of independent completion 30 via conductors 58. After passing through turbine generator 70, the produced well fluid continues to flow into vertical wellbore section 26 and up through well completion 28 for production to a desired surface location. In some embodiments, the well completion 28 may comprise one or more electric submersible pumping systems designed to produce fluid to the surface location while drawing fluid into the lateral wellbore section 24.

[0027] The embodiment illustrated in FIG. 3 illustrates a single packer 42, however additional packers 42 may be used to isolate additional well zones 38 along lateral wellbore section 24. Furthermore, a variety of telemetry systems 62 may be employed to communicate signals between the independent completion 30 and the well completion 28 located in a different wellbore section. As discussed above, the telemetry system may comprise a wireless telemetry system, such as an acoustic telemetry system or an electromagnetic wireless telemetry system. In the specific example illustrated, telemetry system 62 may comprise an electromagnetic wireless telemetry system or an acoustic telemetry system.

[0028] The downhole turbine generator 70, battery 72, inductive coupler 74, and wireless telemetry system 62 may be used in cooperation to fully control and power the independent, intelligent completion 30 located in lateral wellbore section 24. As the turbine generator 70 is rotated by the flowing well fluid, electrical signals are output and those electrical power signals may be rectified into a DC signal for charging the battery 72. When a wireless command from the surface is transmitted to the independent completion 30 via wireless telemetry system 62 to, for example, open a valve or to transmit a sensor reading, the battery 72 sends the correct amount of power to the flow control valve actuator or to the appropriate sensor through the inductive coupler 74.

[0029] Telemetry unit 76, or another suitable independent completion component, may also be used to distribute the power from power unit 44 to all of the electrically powered completion components 52. Feedback may be continuously sent to the surface via the wireless telemetry system 62. The use of power storage device 48 and wireless telemetry system 62 enables operation of and control over the independent completion 30 even during a well shut-in when no production fluid flows. The localized power storage provided by power storage device 48 allows an operator to shut-in the well for a finite period of time while devices 52 are powered by the power storage device 48. Even during shut-in, sensor readings regarding pressure build-up and/or other parameters may be obtained and other well testing can be conducted. The resulting data may be transmitted to the surface with the aid of wireless telemetry system 62 during the finite shut-in period.
If a failure event occurs or if an end of service life for power unit 44 is anticipated, the entire power unit 44 may be removed by releasing the locking mechanism 80. The power unit portion of the inductive coupler 74 is simply pulled or otherwise disengaged from the remainder of the independent completion 30 and retrieved to the surface. For example, applying a pulling force to power unit 44 may be used to cause release of locking mechanism 80 and disengagement of inductive coupler 74. As discussed above, the entire power unit 44 may be designed with a sufficiently small diameter or cross-section so that it may be pulled up through an interior of well completion 28. Removal through the interior of the completion 28 obviates the need to remove any uphole hardware to perform the servicing or replacement operation. After service, the power unit 44 may simply be re-deployed down through well completion 28 and locked into place within the independent completion 30 via locking mechanism 80. As the power unit is moved into position within independent completion 30, the inductive coupler also is again connected to allow for electrical signals to be transmitted from and/or to electrical devices 52.

However, the components of power unit 44, independent completion 30, and overall well system 20 can be adjusted to accommodate a variety of structural, operational, and/or environmental parameters. For example, various combinations of packers, flow control valves, telemetry systems, power generators, power storage devices, sensors and other components may be used to achieve the desired flow control or other downhole functional control. Additionally, the number and arrangement of wellbore sections and well zones along each wellbore section may vary substantially from one well application to another. In some applications, wellbore sections are disposed along lateral wellbores while other applications have at least one wellbore section in a non-lateral, e.g. vertical, wellbore. The technique and mechanisms used to deploy and retrieve the power units also may change from one application to another.

Although only a few embodiments of the present disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

What is claimed is:

1. A system for use in a well, comprising:
   a well completion deployed in a generally vertical wellbore;
   an independent completion deployed in a lateral wellbore, the independent completion comprising a power unit having a power generator and a power storage to store energy generated by the power generator, the power unit being removably engaged within the independent completion to enable removal and re-engagement of the power unit; and
   a wireless telemetry system positioned to communicate signals between the independent completion and the well completion.

2. The system is recited in claim 1, wherein the independent completion further comprises a flow control valve.

3. The system is recited in claim 1, wherein the independent completion further comprises a sensor which receives power from the power storage, wherein data from the sensor is transmitted via the wireless telemetry system.

4. The system is recited in claim 1, wherein the independent completion further comprises a plurality of electrical devices receiving power from the power storage.

5. The system is recited in claim 1, wherein the power storage is coupled to an electrical device via an inductive cooler in the independent completion.

6. The system as recited in claim 1, wherein the power storage comprises a rechargeable battery.

7. The system as recited in claim 1, wherein the power generator comprises a turbine rotated by fluid flowing along the lateral wellbore.

8. The system as recited in claim 1, wherein the wireless telemetry system comprises an electromagnetic wireless telemetry system.

9. The system as recited in claim 1, wherein the wireless telemetry system comprises a pressure pulse system.

10. A method, comprising:
    placing an independent completion in a wellbore section;
    providing the independent completion with a removable power unit having a hydraulically driven power generator coupled to a power storage; and
    communicating data between the independent completion and a second completion located in a second wellbore section.

11. The method as recited in claim 10, wherein communicating comprises communicating data wirelessly.

12. The method as recited in claim 10, wherein communicating comprises communicating data to the second completion located in a generally vertical wellbore section.

13. The method as recited in claim 10, wherein providing comprises coupling the removable power unit with a remainder of the independent completion via an inductive coupler and a lock mechanism.

14. The method as recited in claim 10, wherein providing comprises providing the independent completion with the removable power unit having the hydraulically driven power generator in the form of a turbine and the power storage in the form of a battery.

15. The method as recited in claim 10, further comprising locating the independent completion in a lateral wellbore and using a sensor and a flow control valve in the independent completion to monitor and control flow in the lateral wellbore, wherein communicating comprises communicating data from the sensor to the second completion via wireless telemetry.

16. The method as recited in claim 10, wherein communicating comprises communicating via a wireless, acoustic telemetry system.

17. The method as recited in claim 10, further comprising removing the removable power unit through an interior of the second completion.

18. A system for use in a wellbore, comprising:
   a remote, independent completion deployed in a wellbore, the remote, independent completion comprising a power unit which is selectively engageable and disengageable from a remainder of the remote, independent completion, the power unit comprising a power generator and a power storage.

19. The system as recited in claim 18, wherein the remote, independent completion further comprises a wireless telemetry system.

20. The system as recited in claim 19, further comprising a second, downhole completion in communication with the remote, independent completion via the wireless telemetry system.

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