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(54) Title: A SYSTEM FOR COMPLETING WATER INJECTOR WELLS

(57) Abrégé/Abstract:
A system for completing water injection wells includes an injector well completion system. In an embodiment, an injector well completion system in a formation has a casing string disposed in a wellbore having an annulus. The casing string includes a casing and a perforating gun. The casing string is run into the wellbore and cemented to provide a cemented casing string having the perforating gun. The tubing is run into the wellbore inside the cemented casing string.

ABSTRACT

A system for completing water injection wells includes an injector well completion system. In an embodiment, an injector well completion system in a formation has a casing string disposed in a wellbore having an annulus. The casing string includes a casing and a perforating gun. The casing string is run into the wellbore and cemented to provide a cemented casing string having the perforating gun. The tubing is run into the wellbore inside the cemented casing string.

A System for Completing Water Injector Wells

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a non-provisional of U.S. Application Serial No. 60/972,886 filed on September 17, 2007, which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Water injector wells involve injecting water into the formation. The water may be injected in the formation for purposes such as voidage replacement to maintain pressure, constrain gas cap, optimize well count, and maximize oil rate acceleration through producers. Various completion techniques have been developed in the industry for completion of water injector wells. For instance, conventional completion techniques include use of frac packs, open hole gravel packs, and stand alone screen completions. Drawbacks to conventional completion techniques include that large inner diameters may not be available, which may be required for completing wells with flow control valves used for proper water injection volume distribution in various zones. Drawbacks related to frac packs include their complexity and high expense. In addition, drawbacks related to open hole gravel packs include the typical high expense in achieving high differential pressure zonal isolation, which is often needed for intelligent completion. Drawbacks to stand along screen completions may include insufficient sand control completions.

[0003] Compliance and non-compliance expandable screens have been developed to overcome problems with conventional completion techniques. However, drawbacks to compliance and non-compliance expandable screens may include un-reliability of the expandable screens over long periods. Further drawbacks include that the collapse rating of the compliance expandable screens may be low.

[0004] Consequently, there is a need for zonal isolation in water injector well completions. Further needs include a completion system for completing a water injector well that provides an inner diameter sufficient for the deployment of flow control valves and the like. Additional needs include a completion system that provides functionality of a cased hole for zonal isolation. In addition, needs include a more efficient system for water injector well completions that prevents cross flow between zones and prevents solids production.

BRIEF SUMMARY OF SOME OF THE PREFERRED EMBODIMENTS

[0005] These and other needs in the art are addressed in one embodiment by an injector well completion system in a formation. The system includes a casing string disposed in a wellbore having an annulus. The casing string has casing and a perforating gun. In addition, the casing string is run into the wellbore and cemented to provide a cemented casing string including the perforating gun. The system further includes running tubing into the wellbore inside the cemented casing string.

[0006] In another embodiment, these and other needs in the art are addressed by a method of completing an injector well. The method includes running a casing string in a wellbore having an annulus. The casing string includes a casing and a perforating gun. The method further includes cementing the casing string to provide a cemented casing string that includes the perforating gun. In addition, the method includes running tubing into the wellbore inside the cemented casing string.

[0007] The foregoing has outlined rather broadly features and technical advantages of embodiments in order that the detailed description that follows may be better understood. Additional features and advantages will be described hereinafter that form the subject of the claims. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other embodiments for carrying out the same purposes. It should also be realized by those skilled in the art that such equivalent embodiments do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] For a detailed description of the preferred embodiments, reference will now be made to the accompanying drawings in which:

[0009] Figure 1 illustrates a cross sectional side view of a wellbore with an injector well completion system having perforating guns and flow control valves;

[0010] Figure 2 illustrates a cross sectional view of casing with perforating guns; and

[0011] Figure 3 illustrates a cross sectional side view of a wellbore with an injector well completion system having perforating guns and fixed choke inflow control valves.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] Figure 1 illustrates an embodiment of an injector well completion system 5 having casing string 15 with casing 25 and perforating guns 110 disposed in wellbore 10. Tubing 20, production packer 30, and zonal isolation packers 35 are also disposed in wellbore 10. In the illustrated embodiment, injector well completion system 5 also includes sensor bridle 45 and flow control valves 55. Packers 30, 35 may include any packers suitable for use in wellbore 10. In an embodiment as illustrated in Figure 1, packers 30, 35 have feed through 40 through which sensor bridle 45 passes. Sensor bridle 45 includes sensors 100. Sensors 100 may include any sensors suitable for use in a wellbore 10 such as pressure sensors, temperature sensors, measurement fiber optics, continuous sensors, and discrete sensors. Sensors 100 may also include measurement systems that calculate flow allocation in each zone of a formation.

[0013] In an embodiment as illustrated in Figure 2, perforating guns 110 may be secured to casing 25 on outside surface 125 of casing 25. Perforating gun 110 refers to a device used to perforate formations in preparation for production. Perforating gun 110 may include any suitable size and configuration for perforating cement 50 and/or formation 75. In an embodiment as illustrated in Figure 2, perforating gun 110 includes perforating charge 115. Perforating charge 115 is an explosive device. In some embodiments, perforating charge 115 is a shaped charge. In alternative embodiments (not illustrated), perforating charges 115 are part of casing 25. The perforating charge 115 is designed to perforate formation through cement and the casing 25 to establish communication from tubing bore or annulus 70 to formation 80, 85 and 95.

[0014] In an embodiment as illustrated in Figure 1, casing string 15 with casing 25 and perforating guns 110 is run into wellbore 10 and cemented in place by cement 50 in wellbore 10. Cement 50 may include any cement composition suitable for use in a wellbore. Tubing 20 and packers 30, 35 are run into wellbore 10 after cementing of casing string 15. In some embodiments, tubing 20 and packers 30, 35 are run into wellbore 10 after perforating guns 110 have perforated cement 50 and/or formation 75. In the embodiment as illustrated in Figure 1, casing string 15 includes more than one perforating gun 110. It is to be understood that casing string 15 is not limited to any number of perforating guns 110 but may include one perforating gun 110 or more than one perforating gun 110.

[0015] As shown in Figure 1, injector well completion system 5 also includes flow control valves 55 on tubing 20. Flow control valve 55 may be any type of valve suitable for controlling flow in a wellbore. For instance, examples of suitable flow control valves 55 include sleeve flow control valves and ball flow control valves. Flow control valves 55 may be flow control valves with only open and closed positions or have multiple choke positions. In an embodiment as illustrated in Figure 1, injector well completion system 5 has one flow control valve 55 per zone 80, 85, or 87 that controls the flow of liquid 70 to the perforation guns 110 of each zone 80, 85, or 87. In alternative embodiments (not illustrated), injector well completion system 5 has more than one flow control valve 55 per zone 80, 85, or 87 for directing flow of liquid 70 to the perforating guns 110. Without limitation, injector well completion system 5 isolates the perforating guns 110 of each zone 80, 85, or 87 from the perforating guns 110 of the other zones 80, 85, or 87 by preventing cross-flow between the zones 80, 85, or 87 and creating isolated portions 130. The isolated portions 130 include the perforating guns 110 for each zone 80, 85, or 87. In an embodiment, tubing 20, packers 35 and flow control valves 55 prevent the cross-flow. For instance, injector well completion system 5 isolates zone 80 from zone 85 and zone 85 from zones 80 and 87 by zonal isolation packers 35, and flow control valve 55 preventing cross-flow between the zones. Flow control valves 55 are actuated by control line 60, which runs to surface 65. In some embodiments, control line 60 runs through production packer 30 and zonal isolation packers 35 via feed through 40. Control line 60 may be a hydraulic control line, an electric control line, or a fiber optic control line. Control line 60 communicates to flow control valves 55 whether to open and allow liquid 70 to flow from annulus 120 to isolated portions 130 and also as to whether each zone 80, 85, or 87 is injected with pressure from liquid 70. In alternative embodiments (not illustrated), control line 60 is not controlled from surface 65 but is instead controlled from annulus 120 by controlling the pressure in annulus 120. In such alternative embodiments, control line 60 is a hydraulic control line. In an embodiment, all flow control valves 55 are actuated to provide pressure communication to the perforating guns 110 to about simultaneously actuate all perforating guns 110. In other embodiments, the pressure in annulus 120 is controlled to actuate desired flow control valves 55 without actuating all flow control valves 55, which allows for sequential or individual actuation of perforating guns 110. In an embodiment, flow control valves 55 have an indexing mechanism that allows different chokes to be selected from a plurality of chokes, which allows control of the amount of liquid 70 injected in each zone 80, 85, or 87 through a flow control valve 55. Without being limited by theory, actuating individual flow control valves 55 for individual or sequential actuation of perforating guns 110 may be accomplished for various reasons such as preventing water and/or gas breakthroughs in certain zones. Individual or sequential actuation also allows zones 80, 85, or 87 to be fractured individually.

[0016] As illustrated in Figure 1, liquid 70 is injected into formation 75 through perforations in cement 50 caused by perforating gun 110. In an embodiment, liquid 70 may be any water suitable for water injector wells such as produced water. However, it is to be understood that liquid is not limited to water but may also include any other liquid suitable for use in a wellbore. In alternative embodiments (not illustrated), instead of injecting liquid 70, injector well completion system 5 includes injecting gas. It is to be understood that flow of water is represented in Figure 1 by arrows for illustration purposes. Formation 75 is shown in Figure 1 with zones 80, 85, and 87 and impermeable rock 90. Impermeable rock 90 may be any rock (i.e., shale) that may be incapable of transmitting fluids and may isolate a zone. It is to be understood that Figure 1 shows zones 80, 85, and 87 for illustration purposes only but embodiments may include one zone, two zones, or more than three zones. In the embodiment as illustrated in Figure 1, perforating guns 110 are appropriately located in casing string 15 to inject liquid 70 into desired zones 80, 85, 87 with the injection pressure breaking cement 50 and generating fractures 95 in formation 75. Perforating guns 110 are actuated by pressure communication from flow control valves 55, which provide pressure from annulus 120 to perforating guns 110. Injector well completion system 5 may have one or more than one perforating gun 110 for each zone 80, 85, and 87. In embodiments, cement 50 between each perforating gun 110 provides zonal isolation between each perforating gun 110 or between zones. Zonal isolation refers to providing a seal, barrier, or restriction to prevent communication between zones.

[0017] In an embodiment as illustrated in Figure 1, operation of injector well completion system 5 includes communication via control line 60 to the flow control valves 55 to open the desired flow control valves 55 and select the desired chokes. Liquid 70 pressure is communicated from annulus 120 through the flow control valves 55 to the respective perforating guns 110, which are actuated by the pressure and fired into cement 50 to create perforations in cement 50 and casing. Liquid 70 is then injected through the perforations to create fractures 95 in cement 50 and formation 75. It is to be understood that injector well completion system 5 is not limited to firing perforating guns 110 with pressure in tubing 20 but may include any other suitable method. For instance, perforating guns 110 may be fired by wireless control, control lines from the surface, pressure in tubing 20, or any other suitable method.

[0018] Figure 3 illustrates an embodiment in which injector well completion system 5 includes fixed choke inflow control valves 105 instead of flow control valves 55. In alternative embodiments (not illustrated), injector well completion system 5 includes flow control valves 55 and fixed choke inflow control valves 105. Fixed choke inflow control valves 105 are disposed on tubing 20. In some embodiments, fixed choke inflow control valves 105 are retrievable. Fixed choke inflow control valves 105 may include any suitable inflow control device that has a fixed choke. Without limitation, the fixed choke allows the amount of liquid 70 flow injected in formation 75 through a particular fixed choke inflow control valve 105 to be pre-set. In addition, the fixed choke allows the fixed choke inflow control valves 105 to provide a desired flow distribution to formation 75. Injector well completion system 5 is not limited to inflow control valve 105 being a fixed choke inflow control device but in some embodiments the inflow control valve 105 may be a fixed choke, an orifice, or a passageway inflow control device. In some embodiments, the inflow control valve 105 has a tortuous flow pathway. In an embodiment (not illustrated), each fixed choke inflow control valve 105 includes a back flow check valve to prevent backflow of liquids and solids from formation 75 into annulus 120. Without limitation, examples of suitable back flow check valves include sleeve back flow check valves, ball back flow check valves, concentric choke check valves, and the like. In other embodiments (not illustrated), fixed choke inflow control valve 105 also includes a screen. In alternative embodiments (not illustrated), fixed choke inflow control valve 105 has a screen but not a back flow check valve. Embodiments of back flow check valves and screens are disclosed in co-pending application entitled "A System for Completing Water Injector Wells," which is incorporated by reference in its entirety.

[0019] In an embodiment as illustrated in Figure 3, operation of injector well completion system 5 includes increasing pressure in annulus 120 until the pre-set actuation pressure of perforation gun detonation is achieved. Fixed choke inflow control valves 105 allow liquid 70 pressure from annulus 120 to be communicated through the fixed choke inflow control valves 105 to the respective perforating guns 110, which are actuated by the pressure and fire into cement 50 and casing 125 creating perforations. Liquid 70 is then injected through the perforations to create fractures 95 in cement 50 and formation 75.

[0020] Without limitation, embodiments of injector well completion system 5 prevent cross-flow between zones (i.e., zones 80, 85, and 87). For instance, as shown in Figure 1, cement 50 between each perforating gun 110 provides zonal isolation. With casing string 15 including perforating guns 110 that are run into wellbore 10 with casing 25, injector well completion system 5 provides fluid loss control and well control during deployment of the upper completion. Moreover, injector well completion system 5 provides confirmation of zonal isolation by providing cement 50 between each perforating gun 110. Injector well completion systems 5 also provide large inner diameters.

[0021] It is to be understood that injector well completion system 5 is not limited to injection but may also be applied for production of hydrocarbons from formation 75. In an embodiment, after perforating guns 110 are actuated and fractures 95 are created, pressure in annulus 120 may be reduced to a sufficient pressure at which the hydrocarbons flow from formation 75 through fractures 95 to annulus 120 and flow up annulus 120 for production. Pressure in annulus 120 may be reduced by any suitable method. In an embodiment as illustrated in Figure 1, flow control valves 55 are controlled for sequential or individual production from zones 80, 85, and 87. In other embodiments as illustrated in Figure 1, flow control valves 55 are controlled for about simultaneous production from zones 80, 85, and 87. In embodiments as illustrated in Figure 3, fixed choke inflow control valves 105 are actuated for about simultaneous production from zones 80, 85, and 87.

[0022] Although the embodiments and advantages have been described in detail, it should be understood that various changes, substitutions and alterations may be made herein without departing from the spirit and scope of the invention as defined by the appended claims.

CLAIMS

What is claimed is:

1. An injector well completion system in a formation, comprising:

a casing string disposed in a wellbore comprising an annulus, wherein the casing string comprises a casing and a perforating gun, and wherein the casing string is run into the wellbore and cemented to provide a cemented casing string comprising the perforating gun; and

wherein tubing is run into the wellbore inside the cemented casing string.

2. The injector well completion system of claim 1, further comprising a flow control valve, wherein the flow control valve controls pressure communication from the annulus to the perforating gun.

3. The injector well completion system of claim 2 wherein the flow control valve is retrievable.

4. The injector well completion system of claim 2, further comprising a control line that controls operation of the flow control valve.

5. The injector well completion system of claim 4, wherein the pressure in the control line selects a choke for the flow control valve.

6. The injector well completion system of claim 4, wherein the pressure in the control line is controlled from the surface.

7. The injector well completion system of claim 4, wherein the pressure in the control line is controlled by annulus pressure.

8. The injector well completion system of claim 1, further comprising a fixed choke inflow control valve, wherein the fixed choke inflow control valve controls pressure communication from the annulus to the perforating gun.

9. The injector well completion system of claim 8 wherein the fixed choke inflow control valve is retrievable.

10. The injector well completion system of claim 8, further comprising a back flow check valve.

11. The injector well completion system of claim 1, further comprising a sensor bridle and a sensor.

12. The injector well completion system of claim 1, further comprising more than one perforating gun.

13. The injector well completion system of claim 1, further comprising packers and at least one flow control valve, wherein the packers, the at least one flow control valve, and the tubing isolate each perforating gun from cross-flow from other perforating guns.

14. The injector well completion system of claim 1, further comprising more than one perforating gun, wherein each perforating gun has a back flow check valve that controls liquid flow from the annulus to the each perforating gun.

15. The injector well completion system of claim 12, further comprising packers, wherein the packers, the more than one fixed choke inflow control valve, and the tubing isolate each perforating gun from cross-flow from other perforating guns.

16. The injector well completion system of claim 1, wherein pressure communication from the annulus actuates the perforating gun to create perforations in the cement and casing.

17. The injector well completion system of claim 1, wherein a reduction in annulus pressure allows hydrocarbons to flow from the formation to the annulus.

18. A method of completing an injector well, comprising:

(A) running a casing string in a wellbore comprising an annulus, wherein the casing string comprises a casing and a perforating gun;

(B) cementing the casing string to provide a cemented casing string comprising the perforating gun; and

(C) running at least one flow control valve or fixed choke inflow control device into the wellbore inside the cemented casing string.

19. The method of claim 18, further comprising actuating the perforating gun.

20. The method of claim 18, wherein the casing string comprises more than one perforating gun, and wherein the method further comprises isolating each perforating gun from cross-flow from other perforating guns.

21. The method of claim 20, further comprising actuating the more than one perforating gun sequentially.

22. The method of claim 18 wherein the at least one flow control valve or fixed choke inflow control device is retrievable.

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Application number / numéro de demande: 2639557

Figures: 1, 2, 3

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