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(54) INHIBITING GAS INJECTION INTO A WATER INJECTION WELL

(57) A system for inhibiting air or other corrosive and/or oxidizing gas injection into an underground water injection well(1) comprises a control device (26) which automatically closes a water injection valve(20) when the injection water level in an injection water storage reservoir(12) drops below a selected minimum level.

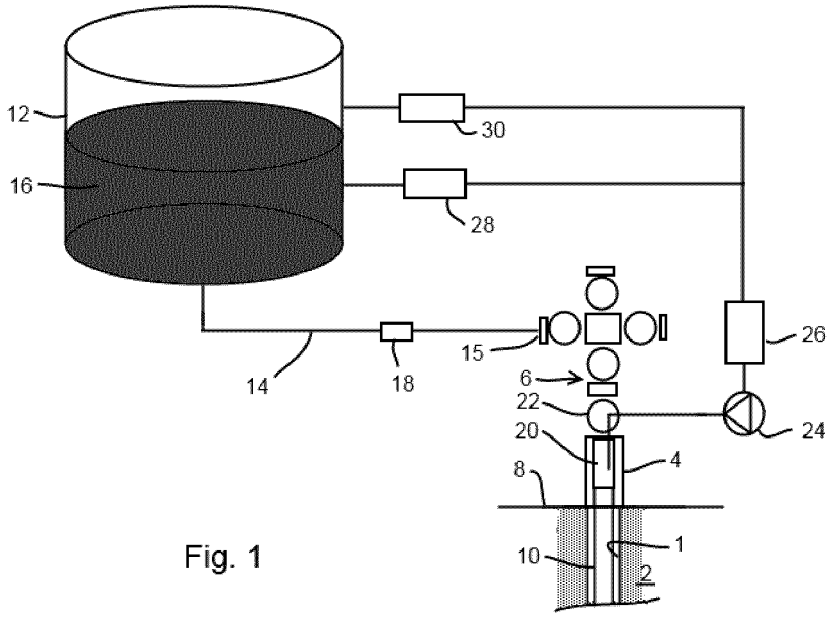

Fig. 1

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Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a method and system for inhibiting air and/or other corrosive and/or oxidising gas injection into an underground water injection well.

[0002] When hydrocarbon oil or gas is produced from an underground oil and/or gas containing formation, it may occur that after a period of time water is concurrently produced with the produced oil or gas. The produced water may be contaminated with oil and/or other constituents, and it may be decided to re-inject the produced water into the earth formation. Such reinjection also may improve recovery of hydrocarbon fluid from the earth formation and may help maintaining the production rate of the field over a longer period of time.

[0003] The document "Water Injection & Produced Water Reinjection at Ravva" by Cairn India Limited discloses a method of injecting produced water into an earth formation. The injection water is pumped by electrical submersible pumps from a depth of around 40 m and fed to a water surge tank. The surge tank is gas blanketed using natural gas to prevent oxygen contamination in the injection water.

[0004] There is a need for an improved system for injecting water into a borehole formed in an earth formation, which obviates the need of gas blanketing the production water and which overcomes other drawbacks of the prior art.

SUMMARY OF THE INVENTION

[0005] In accordance with the invention there is provided a system for inhibiting gas injection into an underground water injection well, the system comprising:

- a water injection conduit extending into the well;
- a water injection valve for selectively allowing water to flow into the conduit via an inlet of the water injection valve;
- an injection water storage reservoir containing a body of water in fluid communication with the inlet of the water injection valve;
- a control device operative to close the water injection valve when the level of the body of water reaches a selected minimum level above said inlet.

[0006] When the water level in the water storage reservoir has dropped to the minimum level and the water injection valve is closed, water that already has entered the conduit continues falling downwards thereby causing a pressure reduction at the upper end of the conduit. Such pressure reduction may lead to fluid being drawn into the conduit, for example via small leaks at connections in a wellhead or a Christmas tree positioned above the borehole. With the system of the invention there is always a (small) column of water present above the inlet of the water injection valve, even after the water injection valve has been closed. Thus, if any fluid is drawn into the conduit by the pressure reduction, such fluid will be water and not air. In this manner it is achieved that oxygen and/or other corrosive and/or oxidizing gas ingress into the water injection conduit is prevented and that thereby the risk of corrosion of the conduit and other wellbore components is mitigated.

[0007] Suitably the reservoir is arranged to allow water of the body of water to flow into the conduit via said inlet by gravity. Furthermore, the control device may be operative to open the water injection valve when the level of the body of water reaches a selected level above said minimum level.

[0008] In a practical embodiment the water injection valve is located in a wellhead at the upper end of the borehole. For example, the conduit may include a water injection tubing connected to a hanger nipple suspended in the wellhead, wherein the water injection valve is positioned in the hanger nipple.

[0009] Suitably a Christmas tree is positioned above the wellhead, wherein the water injection valve is controlled via a control line extending through a housing of the Christmas tree and below a lower master valve of the Christmas tree. The water injection valve may be a hydraulic valve, wherein the control line is a hydraulic control line.

[0010] The invention also relates to a method of inhibiting gas injection into an underground water injection well, the method comprising:

- selectively allowing water to flow into a water injection conduit in the well via an inlet of a water injection valve;
- providing a water storage reservoir containing a body of injection water in fluid communication with the inlet of the water injection valve;
- operating a control device so as to close the water injection valve when the level of the body of water reaches a selected minimum level above said inlet.

[0011] These and other features, aspects and advantages of the method and system according to the invention are described in more detail in the following detailed description of depicted embodiments and in the accompanying claims and abstract.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will be described hereinafter in more detail and by way of example, with reference to the accompanying drawings in which:

Fig. 1 schematically shows an exemplary embodiment of the system of the invention; and

Fig. 2 schematically shows a water injection valve of the exemplary embodiment, in longitudinal sec-

tion.

DETAILED DESCRIPTION OF DEPICTED EMBODIMENTS

[0013] In the following detailed description of depicted embodiments and in the accompanying figures 1 and 2, like reference numerals relate to like components. Depicted features may be combined in different manners.

[0014] Referring to Fig. 1 there is shown a water injection well 1 extending into an earth formation 2, the well 1 being provided with a wellhead 4 and a Christmas tree 6 at surface 8. A conduit in the form of production tubing 10 extends into the well 1 to a depth where water is to be injected into the earth formation 2. The production tubing 10 is fluidly connected to a reservoir 12 via the Christmas tree 6 and a conduit 14 interconnecting the reservoir 12 and the Christmas tree 6 at an inlet 15 thereof. The reservoir 12 contains a body of water 16 that has been produced from a hydrocarbon fluid production well (not shown). A liquid line solenoid valve 18 is provided in the conduit 14 as an emergency shutdown valve.

[0015] A water injection valve 20 is provided at the upper end of the production tubing 10 and below a lower master valve 22 of the Christmas tree 6. The water injection valve 20 is hydraulically operated by a pump 24 and is arranged to selectively allow water to flow from the reservoir 12 into the production tubing 10 via the conduit 14. A control device 26 is provided for controlling operation of the water injection valve 20 via the pump 24 in dependence of the water level in the reservoir 12. Thereto, the reservoir 12 is provided with a first gauge 28 that provides a first signal representing a minimum level of the body of water 16. The minimum level is selected slightly higher than the vertical level of the inlet of the water injection valve 20. The control device 26 is programmed to induce the pump 24 to close the water injection valve 20 upon receiving the first signal. Furthermore, the reservoir 12 is provided with a second gauge 30 providing a second signal representing a selected upper level of the body of water 16 above the minimum level. The control device 26 is programmed to induce the pump 24 to open the water injection valve 20 upon receiving the second signal.

[0016] Referring further to fig. 2 there is shown in more detail a portion of the assembly of wellhead 4 and Christmas tree 6. The assembly includes a tubing head 32 in which the production tubing 10 is suspended on a tubing hanger nipple 34. A tubing head adapter 36 is arranged between the lower master valve 22 and the tubing head 32. The lower master valve 22 may be a conventional gate valve with a gate member (not shown) arranged to slide in transverse direction between an open position and a closed position. The water injection valve 20 comprises a cylindrical housing 38 extending into the hanger nipple 34 and having an annular shoulder 40 that rests on a corresponding annular shoulder 42 of the hanger nipple 34. A tubular upper portion 44 of the housing 38 extends into the lower master valve 22 and is sealed to a cylindrical inner surface 46 thereof by annular seals 42, 44. An interior space 48 of the tubular upper portion 44 is in fluid communication with the production tubing 10 via a number of ports 50 provided in the housing 38.

[0017] Furthermore, the water injection valve 20 comprises a valve member 52 axially movable in a valve chamber 54 of the housing 38 between an open position and a closed position. In the open position water is allowed to flow from the interior space 48 via the ports 50 into the production tubing 10. In the closed position the upper end of the valve member 52 abuts against an annular seat 56 of the housing 38 so as to prevent flow of water from the interior space 48 via the ports 50 into the production tubing 10. A compression spring 58 is provided to bias the valve member 52 to the closed position.

[0018] The valve member 52 is at the lower end thereof provided with a piston 60 arranged in a fluid chamber 62 of the housing 38. The fluid chamber 62 is fluidly connected to the pump 24 via a fluid channel 64 having a first channel portion 64a passing through the housing 38. A second portion 64b of the fluid channel 64 passes through the lower master valve 22, below the gate member thereof. The piston 60, the fluid chamber 62 and the fluid channel 64 are arranged so that the valve member 52 moves to the open position when hydraulic fluid is pumped into the fluid chamber 62 via the fluid channel 64.

[0019] During normal operation the control device 26 induces pump 24 to pump hydraulic fluid into the fluid chamber 62 via fluid channel 64 so as to move the valve member 52 to the open position. Water flows then from the reservoir 12 via the conduit 14 and the Christmas tree 6 into the interior space 48 of the housing 38. From there the water flow via the ports 50 and the production tubing 10 into an open lower section of the well 1 and then further into the earth formation 2.

[0020] Upon the water level in the reservoir 12 reaching the minimum level, the first gauge 28 sends the first signal to the control device 26 which thereby induces the pump 24 to decrease the fluid pressure in the fluid chamber 62. As a result, the compression spring 58 urges the valve member 52 to the closed position so that the ports 50 become closed. The flow of water from the reservoir 12 into the production tubing 10 is thereby stopped. Due to the minimum level of water in the reservoir being slightly higher than the vertical level of the inlet of the water injection valve 20, there will be a small hydrostatic column of water present above the water injection valve 20 after the flow of water has been stopped. Water that already has entered the production tubing 10 continues flowing downwards and thereby causes a reduced fluid pressure in an upper portion of the production tubing 10. In the prior art, such reduced fluid pressure involves the risk of drawing air into the production tubing, for example via small leaks in the wellhead 4 or the Christmas tree 6. Air that has entered the production tubing 10 may lead to enhanced corrosion of the production tubing and eventually may necessitate a full workover of the production

tubing. With the system of the invention, only some water from the small column of water may be drawn into the production tubing after closing the water injection valve 20. In this manner the small column of water prevents air from being drawn into the production tubing 10 after the water injection valve 20 is closed. The risk of corrosion of the production tubing 10 or any other wellbore components is thereby mitigated.

[0021] Thereafter, continued supply of water from the hydrocarbon fluid well to the reservoir 12 leads again to a rise of the water level in the reservoir. After some time the water level in the reservoir 12 reaches the upper level. Thereby the second gauge 30 sends the second signal to the control device 16 which then induces the pump 24 to open the water injection valve 20 so as to allow water to flow again from the reservoir 12 into the production tubing 10. Thus, the water level in the reservoir is maintained between the selected minimum level and the selected upper level.

[0022] With the system of the invention it is achieved that there is always a small column of water present above the upper end of the production tubing, so that ingress of oxygen into the production tubing is prevented.

[0023] Instead of the hydraulic control line for controlling the water injection valve extending through the lower master valve of the Christmas tree, the hydraulic control line may be provided at a separate spool of the wellhead or at a special entrance of the Christmas tree.

[0024] In the light of the foregoing it will be understood that the invention provides an improved method and system for inhibiting air and/or other corrosive and/or oxidising gas injection into an underground water injection well (1) because a control device (26) automatically closes a water injection valve(20) when the injection water level in an injection water storage reservoir (12) drops below a selected minimum level.

Claims

1. A system for inhibiting gas injection into an underground water injection well, the system comprising:

   - a water injection conduit extending into the well;
   - a water injection valve for selectively allowing water to flow into the conduit via an inlet of the water injection valve;
   - an injection water reservoir containing a body of injection water in fluid communication with the inlet of the water injection valve;
   - a control device operative to close the water injection valve when the level of the body of injection water reaches a selected minimum level above said inlet.

2. The system of claim 1, wherein the reservoir is arranged to allow water of the body of water to flow into the conduit via said inlet by gravity.

3. The system of claim 1 or 2, wherein the control device is operative to open the water injection valve when the level of the body of water reaches a selected level above said minimum level.

4. The system of any one of claims 1-3, wherein the water injection valve is located in a wellhead at the upper end of the water injection well.

5. The system of claim 4, wherein the conduit includes a downhole water injection tubing suspended from a hanger nipple in the wellhead of the water injection well and the water injection valve is located in the hanger nipple.

6. The system of claim 4 or 5, wherein a Christmas tree is located above the wellhead, and the water injection valve is controlled via a control line extending through a housing of the Christmas tree and below a lower master valve of the Christmas tree.

7. The system of claim 6, wherein the water injection valve is a hydraulic valve and the control line is a hydraulic control line.

8. A method of inhibiting gas injection into an underground water injection well, the method comprising:

   - selectively allowing water to flow into the well via an inlet of a water injection valve;
   - providing an injection water storage reservoir containing a body of water in fluid communication with the inlet of the water injection valve;
   - operating a control device so as to close the water injection valve when the level of the body of water reaches a selected minimum level above said inlet.

9. The method of claim 8, further comprising arranging the reservoir so as to allow water of the body of water to flow into a conduit extending into the well via said inlet by gravity.

10. The method of claim 8 or 9, further comprising operating the control device so as to open the water injection valve when the level of the body of water reaches a selected level above said minimum level.

11. The method of any one of claims 8-10, wherein the injection water is injected via the water injection well into a surrounding crude oil and/or natural gas containing formation to enhance production of crude oil and/or natural gas from the formation.

12. The method of any one of claims 8-11, wherein the water comprises an aqueous well effluent, which has

been concurrently produced with the produced crude oil and/or natural gas, which aqueous well effluent is contaminated with crude oil, gaseous and/or other non-aqueous well effluents and is re-injected into the earth formation.

13. The method of claim 12, wherein the method is used to inhibit injection of air, methane, hydrogen sulphide and/or other corrosive and/or oxidising gaseous fluids into the water injection well and/or the surrounding crude oil and/or natural gas containing formation.

14. The method of any one of claims 8-10, wherein the method is used to inhibit corrosion of well equipment in a water injection well through which water is injected into an underground aquifer or other permeable formation.

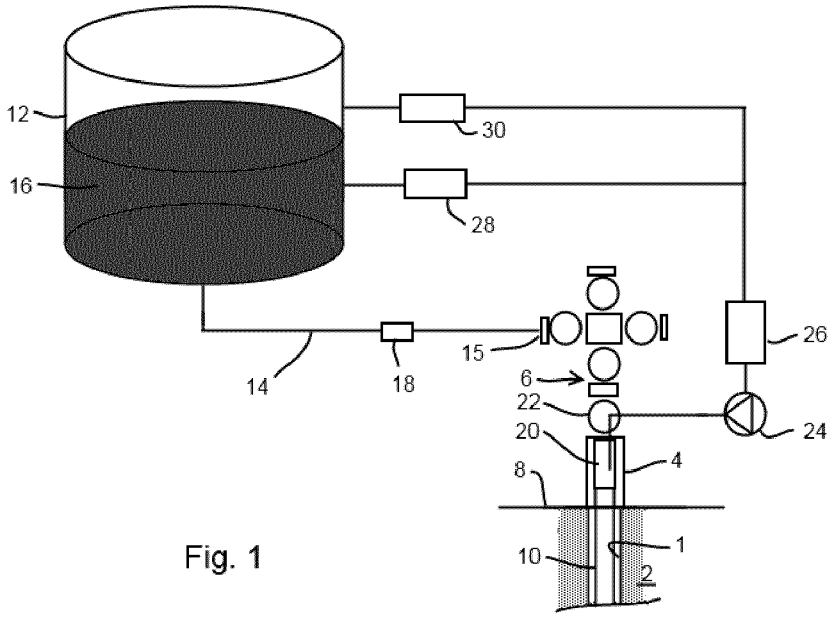
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Fig. 1

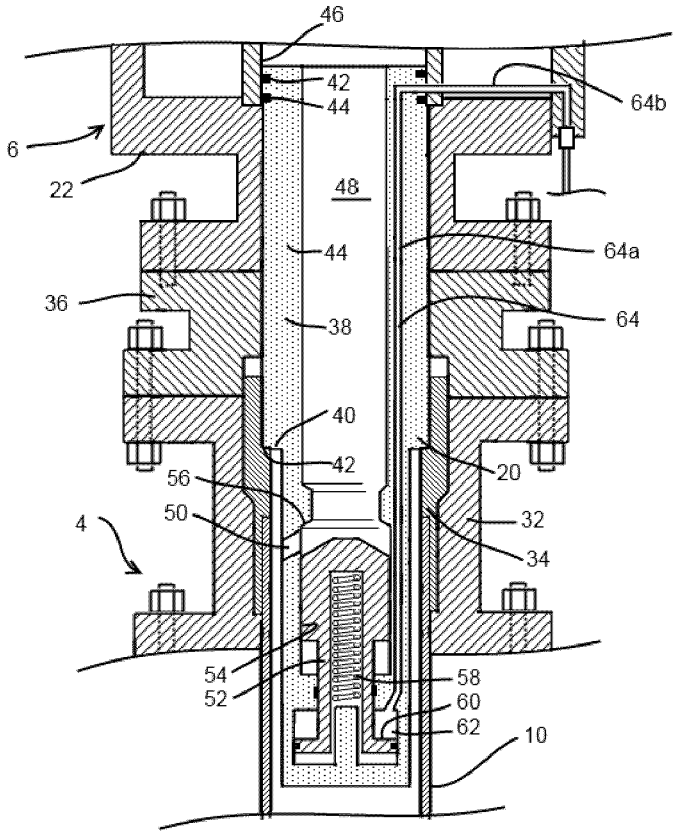
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Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 14 20 0349

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2 357 189 A (ERWIN RANSOME W) 29 August 1944 (1944-08-29)	1-6, 8-11,13, 14	INV. E21B33/037 E21B34/02
Y	* page 2, column 1, line 53 - page 2, column 2, line 75 *	7,12	E21B43/20

Y	US 4 009 756 A (ZEHREN JAMES N) 1 March 1977 (1977-03-01) * column 1, line 13 - line 28; figure 2 *	7,12	

TECHNICAL FIELDS SEARCHED (IPC)

E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	27 May 2015	Ott, Stéphane

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 20 0349

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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27-05-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2357189 A	29-08-1944	NONE	
US 4009756 A	01-03-1977	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82