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(71) Applicant: **Shell Internationale Research Maatschappij B.V.**
2596 HR The Hague (NL)

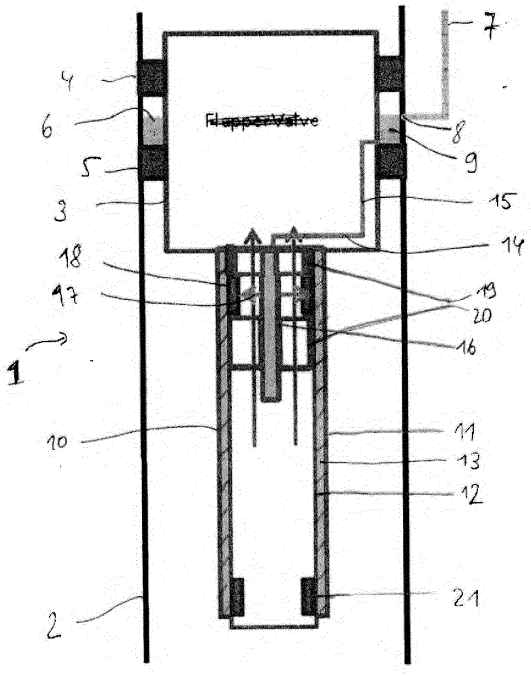
(72) Inventor: **GORT, Edwin, Hilbert**
9405 TA Assen (NL)

(74) Representative: **Shell Legal Services IP**
p/a Carel van Bylandtlaan 16
2596 HR Den Haag (NL)

(54) **METHOD AND SYSTEM FOR INJECTING A TREATING FLUID INTO A WELL BELOW A SAFETY VALVE**

(57) A method for injecting a treating fluid into a hydrocarbon fluid production well via an injection conduit (15) which is at least partially formed by an annular space (13) between inner (12) and outer walls (11) of a double-walled tubular string (10) suspended within the well; as well as a system for injecting a treating fluid into a hydrocarbon fluid production well, the system comprising a flapper valve (3) in fluid connection with an injection conduit (15) which is at least partially formed by an annular space (13) between inner (12) and outer walls (11) of a double-walled tubular string (10) suspended within the well.

Fig. 1



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Description

BACKGROUND OF THE INVENTION

[0001] The invention relates to a method and system for injecting a treating fluid into a well, in particular a well producing hydrocarbon fluid.

[0002] The treating fluid may serve to dissolve solid and/or liquid deposits and/or generate a foam that is easily lifted to surface.

[0003] Currently for wet gas production wells which suffer from liquid loading there are a couple of solutions/techniques to increase the Ultimate Recovery of the well. The options include installation of Velocity Strings, Capillary Strings and/or pumps.

[0004] A Velocity String can be installed in a gas well in order to narrow the cross-sectional area of the production tubing and therefore increase the wet gas velocity such that any solids and/or condensed water and/or other condensates are lifted to the earth surface and do not accumulate at the bottom of the wells.

[0005] A Capillary String is a small diameter flexible injection tube through which a foam generating agent, which typically contains a surfactant, is injected to the bottom of the well, so that it will generate a foam upon contact with water and/or other condensates, which foam has low density than the liquids so that liquids can be easier lifted to surface.

[0006] Nowadays all these techniques are separated from each other. So it is possible to install a velocity string for increasing the flow velocity, and also a separate capillary string for foam generation. As these are separated installations, that increases the complexity and difficulty to the operation.

[0007] A known downhole foam generation method and system for wet gas well deliquification are disclosed in US patent 7,198,099.

[0008] In the known system a foam generating agent is injected into a lower part of a wet gas production well via a small diameter foam generating agent injection tube that is suspended in the production tubing below a flapper type Surface Controlled Sub-Surface Safety Valve (SCSSSV) that is actuated via a hydraulic line through which the foam generating agent is injected at an elevated pressure to keep the SCSSSV open.

[0009] A disadvantage of the known method and system is that the small diameter foam generating agent injection conduit is a fragile piece of equipment that may vibrate and be damaged by produced sand or rock particles in the produced wet gas stream and that the damaged conduit may break and obstruct the SCSSSV.

[0010] There is a need for an improved method and system that overcome these and other drawbacks of the known method and system.

SUMMARY OF THE INVENTION

[0011] In accordance with the invention there is provided a method for injecting a treating fluid into a hydrocarbon fluid production well via an injection conduit, which is at least partially formed by an annular space between inner and outer walls of a double-walled tubular string suspended within the well.

[0012] The invention moreover provides a system for injecting a treating fluid into a hydrocarbon fluid production well, the system comprising a flapper valve and an injection conduit in fluid connection which is at least partially formed by an annular space between inner and outer walls of a double-walled tubular string suspended within the well.

[0013] In some embodiments, the double-walled tubular string is connected to a downhole side of a flapper valve that is mounted within a production tubing inside the well. The double-walled tubular string can be suspended from the flapper valve.

[0014] In some embodiments, a hydraulic control line for the flapper valve and a transfer conduit for treating fluid from the hydraulic control line to the annular space are provided, and the treating fluid is passed via the hydraulic control line and the transfer conduit to the annular space for injection into the hydrocarbon fluid production well.

[0015] In some embodiments the transfer conduit comprises a back pressure valve. The back pressure valve can serve to hold open the flapper valve and/or inject the treating fluid into the annular space.

[0016] In some embodiments, the inner wall of the double walled tubular string comprises at least one sleeve valve. In particular, the treating fluid can be injected from the annular space into the interior of the double-walled tubular string through such sleeve valve. Suitably such injection sleeve valve can be provided at a lower part or lower end of the double-walled tubular conduit. Alternatively or in addition, a sleeve valve can be provided as part of the transfer conduit for treating fluid from the hydraulic control line to the annular space. Suitably such sleeve valve is provided at an upper part or upper end of the double-walled tubular conduit. Suitable sleeve valves can for example be a Side Sliding Door (SSD) valve.

[0017] In some embodiments the well is a wet natural gas production well and the treating fluid comprises a foam generating agent. Suitably the foam generating agent can be injected into a lower section of the well to generate a low density foam upon contact with condensed water and/or other condensates that is lifted by the wet gas production stream to production facilities at the earth surface.

[0018] In some embodiments, especially for use in a gas producing well, the double-walled tubular string is a double-walled velocity string.

[0019] In some embodiments, the double walled tubular string is connected to a downhole side of the flapper valve, e.g. suspended from the downhole side of the flapper valve.

[0020] In some embodiments, the system further com-

prises a hydraulic control line for the flapper valve, and a transfer conduit for treating fluid from the hydraulic control line to the annular space. The transfer conduit can further comprise a back pressure valve.

[0021] In some embodiments the flapper valve is a sub-surface safety valve surface, such as a surface retrievable sub-surface safety valve, and can in particular be a so-called Tubing Retrievable (TRSSSV).

[0022] It will be understood that the method and system according to one aspect of the invention facilitate easy and safe integration of the functions of a conventional Capillary String and a conventional Velocity String. It does not require a Bottom Hole Assembly of Capillary, therefore increases the reliability of the installation and mitigates a need to run capillary coil into the well. After installing the velocity string it is possible to install the capillary installation with slickline equipment.

[0023] These and other features, embodiments and advantages of the method and system according to the invention are described in the accompanying claims, abstract and the following detailed description of a non-limiting embodiment depicted in the accompanying drawing, in which description reference numerals are used which refer to corresponding reference numerals that are depicted in the drawings.

[0024] Objects and other features depicted in the figure and/or described in this specification, abstract and/or claims may be combined in different ways by a person skilled in the art.

BRIEF DESCRIPTION OF THE DRAWING

[0025] Figure 1 is a schematic longitudinal sectional view of a well into which a treating fluid is injected via a double-walled tubular string in accordance with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0026] Figure 1 shows a system 1 for injecting a treating fluid into a hydrocarbon fluid production well in accordance with the invention. The system 1 is arranged in a surrounding wellbore in an earth formation (not shown) as part of a hydrocarbon fluid production well.

[0027] The system 1 in the embodiment as shown comprises a production tubing 2 in which a Tubing Retrievable Sub-Surface Safety Valve (TRSSSV) or other flapper valve 3 is suspended. In this embodiment the flapper valve 3 is suspended by means of two pairs of seals 4 and 5, such that an annular region 6 is formed between the seals 4, 5, the outer surface of the valve 3 and the inner surface of the production tubing 2. A hydraulic control 7 line for the flapper valve is connected to a fluid port 8 through which a treating fluid 9, such as a foam generating agent, can be passed into the annular region 6.

[0028] An injection conduit in the form of a double-walled tubular string, in this embodiment a velocity string 10, is suspended from the flapper valve 3 and comprises an outer wall 11 and an inner wall 12 between which an annular space 13 is formed. A transfer conduit 14 is provided which comprises a receiving conduit part 15 in direct fluid communication with the control line 7, a back pressure valve 16 (in this embodiment concentric with the tubular string 10), and a distribution conduit part 17 providing fluid communication from the back pressure valve 16 to the annular space 13, in this embodiment via a sleeve valve. In this embodiment the sleeve valve 18 is a Side Sliding Door (SSD) valve in an upper part of the inner wall 12 of the double-walled velocity string 10.

[0029] Optionally the distribution conduit 17 is arranged within the double-walled velocity string 10 by means of a cross-over assembly in an upper part of the double-walled velocity string 10. This cross-over assembly as shown contains seals 19,20 extending below and above; and therebetween the distribution part 17 of the transfer conduit 14 is arranged. The seals 19,20 are suitably inline with the Inner Diameter(ID) of the velocity string 10 to reduce any risk resulting from erosion.

[0030] A further sleeve valve, SSD valve 21, is arranged near a lower end of the inner wall 12. The lower sleeve valve, which can also be referred to as a lower cross-over, allows selective opening or closing the bottom part of the double-walled tubular string, such as to enable injection near perforations. The double walled tubular string can extend for a short or long distance into the well underneath the flapper valve, in some embodiments it can be 10 m or more, 100 m or more, 500 m or more, such as 1 km or more long.

[0031] Now an example of the operation of the method of the invention with the system 1 as shown will be discussed, wherein the hydrocarbon fluid production well is a wet gas production well. It can be desired during production operation to generate foam at the downhole end of the velocity string 10, e.g. when the flow velocity increase caused by the velocity string is not anymore sufficient to remove the liquid components from the bottom of the wet gas well. To this end, a foam generating agent, e.g. a surfactant or a foaming agent of a type as generally known in the art, can be passed down the control line for the flapper valve and into the annular space 13. The sleeve valves 18 and 21 are operated using e.g. a manipulation tool such as a positioning tool or lock-open tool via slickline or wireline. Via the receiving part 15 of the transfer conduit 14 the foaming agent flows to the back pressure valve 16, which is operated so as to keep the flapper valve open while passing the foam generating agent via distribution conduit 15 and sleeve valve 18 into the annulus 13 of the double-walled velocity string 10, from where it is injected via sleeve valve 21 into the lower part of the velocity string 10 in the hydrocarbon fluid producing well. When the foam generating agent gets into contact with condensed water and/or other condensates in the wet gas stream 21, a lower density foam is created, such that the foam is easily lifted by the wet gas stream 21 to production facilities at the earth surface (not shown).

[0032] The method and system according to the inven-

tion provide the possibility to install a Velocity string and afterwards operate for inject foam generating agent (similar to a capillary string), but without the need of installing a separate Capillary installation. A conventional capillary string installation has several disadvantages. One of them is that the small inner diameter it can relatively easily block which will result in failure of the capillary installation. This solution is heavily reduced in components, minimizing the risk of failures. This will maximize Ultimate Recovery of a wet gas production well.

[0033] Furthermore the method and system according to the invention increase the reliability because a conventional capillary string installation for fluid injection would include a complex Bottom Hole Assembly including valves, which would he arranged in the part of the wellbore filled with liquid, and which is prone to blockages. Another benefit is significantly reduces the cost of because no separate Capillary coil running equipment is needed.

[0034] The embodiment discussed hereinabove relates to a gas production well, but the invention can also be beneficial in a hydrocarbon fluid production well wherein the fluid comprises oil, such as an oil well or a well producing oil and gas. In all cases there can be a water or brine component in the produced fluid. For example, into oil wells surfactants or other chemical agents can be injected as treating fluids, such as to enhance production and/or dissolve liquid and/or solid components.

[0035] Therefore, the method, system and/or any products according to present invention are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein.

[0036] The particular embodiments disclosed above are illustrative only, as the present invention may be modified, combined and/or practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein.

[0037] Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below.

[0038] It is therefore evident that the particular illustrative embodiments disclosed above may be altered, combined and/or modified and all such variations are considered within the scope of the present invention as defined in the accompanying claims.

[0039] While any methods, systems and/or products embodying the invention are described in terms of "comprising," "containing," or "including" various described features and/or steps, they can also "consist essentially of" or "consist of" the various described features and steps.

[0040] All numbers and ranges disclosed above may vary by some amount. Whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range is specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values.

[0041] Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee.

[0042] Moreover, the indefinite articles "a" or "an", as used in the claims, are defined herein to mean one or more than one of the element that it introduces.

[0043] If there is any conflict in the usages of a word or term in this specification and one or more patent or other documents that may be cited herein by reference, the definitions that are consistent with this specification should be adopted.

Claims

1. A method for injecting a treating fluid into a hydrocarbon fluid production well via an injection conduit which is at least partially formed by an annular space between inner and outer walls of a double-walled tubular string suspended within the well.

2. The method of claim 1, wherein the double-walled tubular string is connected to a downhole side of a flapper valve that is mounted within a production tubing inside the well.

3. The method of claim 2, wherein a hydraulic control line for the flapper valve and a transfer conduit for treating fluid from the hydraulic control line to the annular space are provided, and wherein the treating fluid is passed via the hydraulic control line and the transfer conduit to the annular space for injection into the hydrocarbon fluid production well.

4. The method of claim 3, wherein the transfer conduit comprises a back pressure valve.

5. The method of any one of claims 1-4, wherein the inner wall of the double walled tubular string comprises at least one sleeve.

6. The method of any one of claims 1-5, wherein the well is a wet natural gas production well and the treating fluid comprises a foam generating agent.

7. A system for injecting a treating fluid into a hydrocarbon fluid production well, the system comprising a flapper valve and an injection conduit in fluid connection which is at least partially formed by an annular space between inner and outer walls of a double-walled tubular string suspended within the well.

8. The system of claim 7, wherein the double-walled tubular string is a double-walled velocity string.

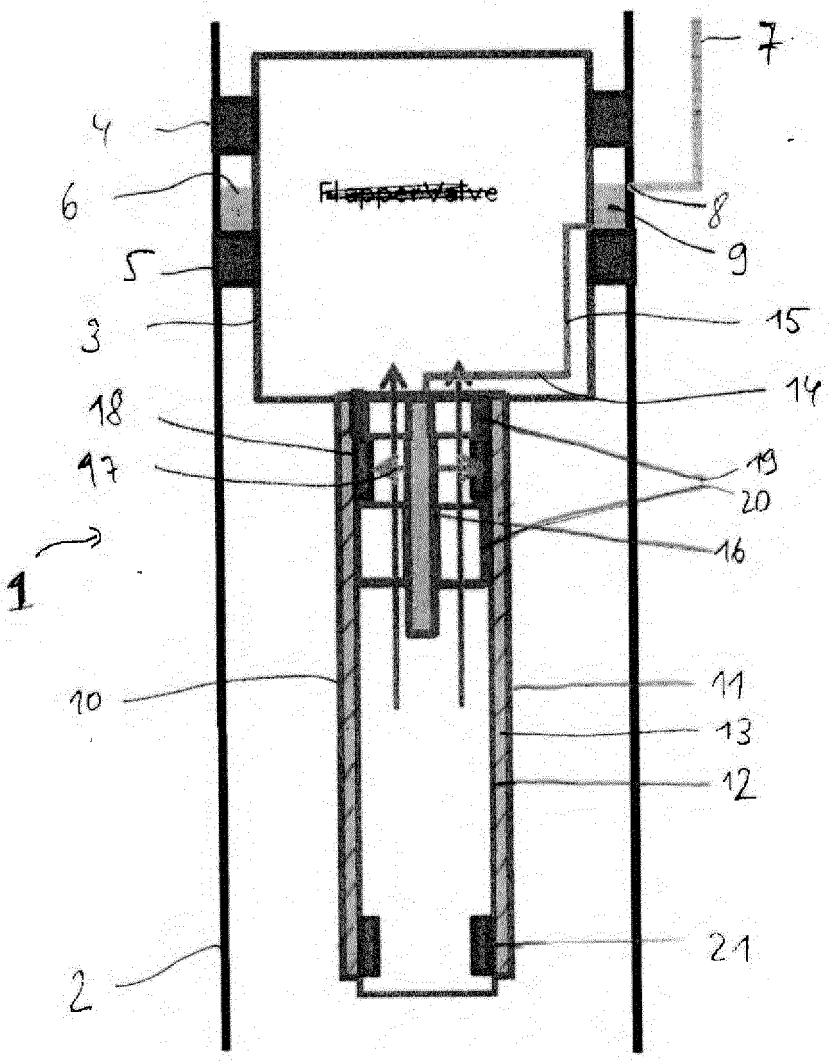
9. The system of claim 7 or 8, wherein the double walled tubular string is connected to a downhole side of the flapper valve.

10. The system of any one of claims 7-9, further comprising a hydraulic control line for the flapper valve, and a transfer conduit for treating fluid from the hydraulic control line to the annular space.

11. The system of claim 10, wherein the transfer conduit further comprises a back pressure valve.

12. The system of claim any one of claims 7-11, wherein the double walled tubular string comprises at least one sleeve valve.

Fig. 1



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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 5215

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y,D	US 7 198 099 B2 (LUGTMEIER LUBBERTUS [NL] ET AL) 3 April 2007 (2007-04-03) * column 4, line 45 - column 5, line 8 * * column 6, lines 28-38 *	1-12	INV. E21B34/10 E21B43/12 E21B43/25
Y	US 2008/271893 A1 (HILL THOMAS G [US] ET AL) 6 November 2008 (2008-11-06) * paragraphs [0060] - [0063], [0067] *	1-12	
Y	US 2015/000929 A1 (VEEKEN CORNELIS ADRIANUS MARIA [NL] ET AL) 1 January 2015 (2015-01-01) * paragraphs [0079], [0080], [0084], [0087] *	5,12	

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
The Hague	2 May 2017	Garrido Garcia, M

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 19 5215

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02-05-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 7198099 B2	03-04-2007	AT 363016 T	15-06-2007
		AU 2004287977 A1	19-05-2005
		BR PI0416256 A	09-01-2007
		CA 2544594 A1	19-05-2005
		CN 1890453 A	03-01-2007
		DE 602004006643 T2	17-01-2008
		EP 1689971 A1	16-08-2006
		NO 338476 B1	22-08-2016
		NZ 546934 A	29-01-2010
		RU 2350738 C2	27-03-2009
		US 2006021750 A1	02-02-2006
		WO 2005045183 A1	19-05-2005
US 2008271893 A1	06-11-2008	AU 2006254949 A1	14-12-2006
		BR PI0610879 A2	03-08-2010
		CA 2611101 A1	14-12-2006
		DK 1888873 T3	27-01-2014
		EG 24998 A	21-04-2011
		EP 1888873 A2	20-02-2008
		NO 337872 B1	04-07-2016
		US 2008271893 A1	06-11-2008
		US 2010186968 A1	29-07-2010
		WO 2006133351 A2	14-12-2006
US 2015000929 A1	01-01-2015	AU 2013220510 A1	31-07-2014
		CA 2861417 A1	22-08-2013
		CN 104126051 A	29-10-2014
		EP 2815060 A1	24-12-2014
		US 2015000929 A1	01-01-2015
		WO 2013120837 A1	22-08-2013

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 7198099 B **[0007]**