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(54) ARTIFICIAL LIFT METHOD

(57) The present invention relates to an artificial lift method for reducing a hydro-static pressure of a fluid column in a top part of a well, the well comprises a casing and a production tubing having the fluid column and being arranged within the casing, the well further comprises a main barrier between the casing and the production tubing creating an annular space above the main barrier, the production tubing has at least one gas lift valve arranged above the main barrier, the annular space is fluidly connected to a feeding inlet arranged in the top of the well, comprising providing a liquid, providing a gas, mixing the gas into the liquid upstream of the feeding inlet for providing an gaseous liquid having a first gas content, introducing the gaseous liquid at a first pressure into the annular space via the feeding inlet, displacing a fluid in the annular space, and reducing the hydro-static pressure in the fluid column by allowing the gaseous liquid to flow into the production tubing through the gas lift valve.

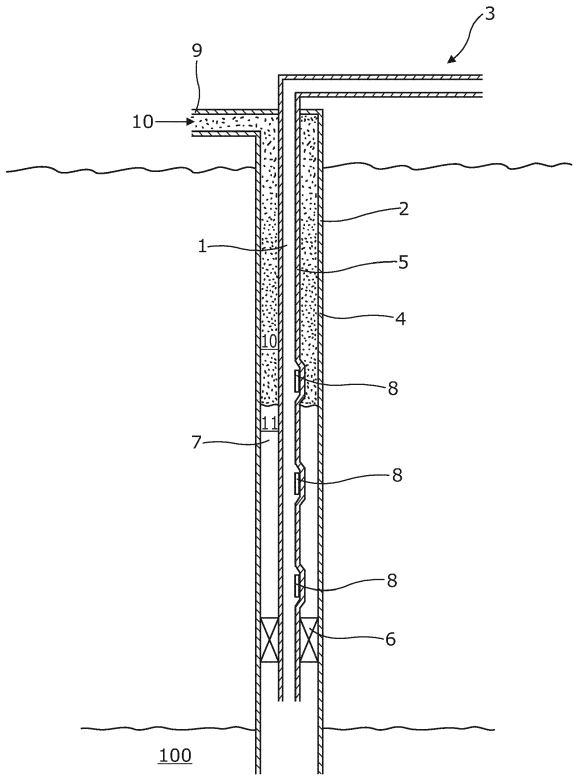

Fig. 1

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Description

[0001] The present invention relates to an artificial lift method for reducing a hydro-static pressure of a fluid column in a top part of a well, the well comprises a casing and a production tubing having the fluid column and being arranged within the casing, the well further comprises a main barrier between the casing and the production tubing creating an annular space above the main barrier, the production tubing has at least one gas lift valve arranged above the main barrier, the annular space is fluidly connected to a feeding inlet arranged in the top of the well, comprising providing a liquid, providing a gas, mixing the gas into the liquid upstream of the feeding inlet for providing an gaseous liquid having a first gas content, introducing the gaseous liquid at a first pressure into the annular space via the feeding inlet, displacing a fluid in the annular space, and reducing the hydro-static pressure in the fluid column by allowing the gaseous liquid to flow into the production tubing through the gas lift valve.

[0002] Over the producing lifetime of an oil well, the bottomhole pressure that sustains natural production will eventually drop so low that the well will either stop flowing or fail to produce an economic oil rate. When this occurs, significantly volumes of oil may be left behind. To recover this oil and improve field productivity, artificial lift solutions can be implemented. They involve either pumping the oil to the surface or changing the properties of the well fluid, allowing reservoir pressure to produce the oil to surface.

[0003] When a well is not producing a significantly amount of hydrocarbons, such as oil, to be profitable or if the well is not producing at all, then gas lift can be initiated to reduce the hydrostatic pressure of the fluid column in the upper part of the production casing so that the pressure in the reservoir is able to force the hydrocarbon-containing fluid into and upwards in the production casing and thus increase the flow rate and profitability. Gas is introduced from surface through gas lift valves in the production casing.

[0004] Unfortunately, traditional gas lift technologies have design limitations, such as limits on the gas-injection rate for stable tubing and casing fluid flow, low maximum operating pressure and unreliable backpressure systems. These constrains prevent known gas lift methods from meeting the safety requirements in high-pressure operations, and preclude their use in deepwater and subsea completions.

[0005] It is an object of the present invention to wholly or partly overcome the above disadvantages and drawbacks of the prior art. More specifically, it is an object to provide an improved artificial lift method which is able to initiate or increase the flow rate also in deepwater subsea or high pressure wells while meeting the safety requirements.

[0006] The above objects, together with numerous other objects, advantages and features, which will become evident from the below description, are accomplished by a solution in accordance with the present invention by an artificial lift method for reducing a hydro-static pressure of a fluid column in a top part of a well, the well comprises a casing and a production tubing having the fluid column and being arranged within the casing, the well further comprises a main barrier between the casing and the production tubing creating an annular space above the main barrier, the production tubing has at least one gas lift valve arranged above the main barrier, the annular space is fluidly connected to a feeding inlet arranged in the top of the well, comprising:

- providing a liquid,
- providing a gas,
- mixing the gas into the liquid upstream of the feeding inlet for providing an gaseous liquid having a first gas content,
- introducing the gaseous liquid at a first pressure into the annular space via the feeding inlet,
- displacing a fluid in the annular space, and
- reducing the hydro-static pressure in the fluid column by allowing the gaseous liquid to flow into the production tubing through the gas lift valve.

[0007] In one embodiment the artificial lift method may further comprise increasing the gas content of the gaseous liquid to a second gas content being higher than the first gas content by mixing more gas into the liquid upstream of the feeding inlet. Also, the artificial lift method may further comprise increasing the gas content of the gaseous liquid to a third gas content being higher than the second gas content by mixing more gas into the liquid upstream of the feeding inlet.

[0008] Said first gas content may be at least 60 volume% gas.

[0009] Further, the second gas content may be at least 70 volume% gas.

[0010] Moreover, the third gas content may be at least 85 volume% gas.

[0011] In another embodiment the artificial lift method may comprise decreasing the gas content of the gaseous liquid by mixing less gas into the liquid upstream of the feeding inlet.

[0012] Additionally, the artificial lift method may comprise detecting the hydro-static pressure in the fluid column.

[0013] Furthermore, the artificial lift method may comprise introducing a gas into the annular space.

[0014] Also, the artificial lift method may comprise increasing the pressure of the gaseous liquid to a second pressure higher than the first pressure.

[0015] Further the artificial lift method may comprise detecting the pressure and/or flow in the fluid column.

[0016] Moreover, the artificial lift method may comprise detecting the content of the fluid in the fluid column.

[0017] Additionally, the artificial lift method may comprise introducing a tracer fluid into the liquid.

[0018] Furthermore, the well may be a subsea well

having a reservoir pressure above 34 MPa (5.000 psi).

[0019] Additionally, the well may be a high pressure well, i.e. having a bottomhole pressure above 10,000 PSI (68 MPa)

[0020] The gas may be carbon dioxide, natural gas, methane gas, nitrogen, or a mixture thereof.

[0021] The liquid may be seawater.

[0022] Also, the fluid column may comprise hydrocarbon-containing fluid.

[0023] An artificial lift method wherein more than one gas lift valve may be arranged in the production tubing.

[0024] Further, the fluid column may comprise a heavy liquid or seawater.

[0025] The invention and its many advantages will be described in more detail below with reference to the accompanying schematic drawings, which for the purpose of illustration show some non-limiting embodiments and in which

[0026] Fig. 1 shows a cross-sectional view of a well having production tubing within a casing.

[0027] All the figures are highly schematic and not necessarily to scale, and they show only those parts which are necessary in order to elucidate the invention, other parts being omitted or merely suggested.

[0028] Fig. 1 shows a well 3 comprising a casing 4 and a production tubing 5 arranged within the casing 4. The well is either not producing or not producing a significant amount of hydrocarbons to be profitable. In order to increase the flow rate or initiate flow of production fluid up the well, the hydro-static pressure of a fluid column 1 in a top part 2 of the well 3 in the production tubing needs to be reduced. The well further comprises a main barrier 6 between the casing 4 and the production tubing 5 creating an annular space 7 above the main barrier 6. The production tubing has three gas lift valves 8 arranged above the main barrier. The annular space 7 is fluidly connected to a feeding inlet 9 arranged in the top of the well 3. When having a high pressure well, i.e. having a bottomhole pressure above 10,000 PSI (68 MPa), there is an increased risk of providing known gas lift where gas is introduce down the annular space 7 and in through the gas lift valves 8 due to a lack of pressure control.

[0029] Therefore, in Fig. 1 both a liquid and a gas is provided and mixed upstream of the feeding inlet for providing a gaseous liquid 10 as the artificial lifting fluid having a first gas content. Then the gaseous liquid 10 is introduced at a first pressure into the annular space 7 via the feeding inlet 9 displacing a fluid 11 present in the annular space 7 until reaching the gas lift valve 8. The hydro-static pressure in the fluid column is then reduced by allowing the gaseous liquid to flow into the production tubing 5 through the gas lift valve 8.

[0030] By using gaseous liquid as artificial lifting fluid in stead of gas, the well pressure is easily controlled when initiating the artificial lift. Then the gas content of the gaseous liquid is increased over time to a second gas content being higher than the first gas content by mixing more gas into the liquid upstream of the feeding inlet. And when the well pressure is still under control, the gas content of the gaseous liquid is further increased to a third gas content being higher than the second gas content by mixing more gas into the liquid upstream of the feeding inlet. By increasing the gas content gradually, the well pressure can be kept under control during the artificial lifting operation since gaseous liquid is much more controllable than gas. When gradually increasing the gas content, the gas content of the artificial lifting fluid may at the end be as much as 100% and the lift with gas is thus gradually introduced while being able to control the well pressure and stop if the well pressure seems to become uncontrollable. In this way, gas lift can be introduced gradually but stopped before the artificial lifting fluid is 100% gas if the well pressure becomes too fluctuating to continue the gradually increasing of gas content.

[0031] The artificial fluid is a gaseous liquid such as soda when the liquid and gas is mixed and thus the gaseous liquid is in the beginning of the artificial method still in the liquid phase and thus pressure controllable. The first gas content is at least 60 volumen percentage (vol%) gas. After a certain time, the gas content is increased either gradually or in one step to the second gas content to be at least 70 vol% gas. After a certain time, the gas content is increased further either gradually or in one step to the third gas content to be at least 85 vol% gas.

[0032] If the well pressure is detected to be too fluctuating, the gas content of the gaseous liquid is decreased by mixing less gas into the liquid upstream of the feeding inlet. The detection of well control can be detecting the hydro-static pressure in the fluid column. When the well pressure is no longer too fluctuating the gas content may be further increased or the if the well is producing in a satisfying manner, the gas content is kept constant. The gas content may be increased until pure gas is introduced into the annular space.

[0033] After introducing the gaseous liquid into the annular space, the pressure of the gaseous liquid may be increased to a second pressure higher than the first pressure and thereby reducing the hydrostatic pressure even further. Furthermore, some gas lift valves are controlled by pressure and thus by increasing the pressure the first gas lift valve can be closed and the next opened so that the gaseous liquid/artificial lifting fluid is forced further down the annular space and lifting more of the liquid column in the production tubing. While introducing the gaseous liquid, the pressure and/or flow in the fluid column is detected. Furthermore, the content of the fluid in the fluid column may be detected so to detect when the well has start producing again.

[0034] In order to detect when a gaseous liquid having a certain gas content has been circulated down the annular space and up the production tubing, a tracer fluid is introduced into the gas and/or liquid or the mixture thereof. In this way, the operator can follow the artificial lifting operation precisely at every stage of the operation. So when detecting a certain tracer when the well pressure starts to fluctuate too much, the operator can easier eval-

uate at which gas content the well pressure was more stable.

[0035] The well is a subsea well having a reservoir 100 having a reservoir pressure above 34 MPa (5,000 psi) but the artificial lift method is also suitable for a high pressure well having a reservoir pressure above 68 MPa (10,000 psi). The gas is carbon dioxide, natural gas, methane gas, nitrogen, or a mixture thereof. The liquid is preferably seawater. The fluid column comprises hydrocarbon-containing fluid, acid, heavy liquid, such as 1,1,2,2-tetrabromoethan, potassium tetraiodomercurate bromoform, diiodomethane, potasium or sodium polytungstate, or seawater or a mixture thereof.

[0036] When using gaseous liquid as artificial fluid, the artificial lift can in some wells lower the lifting point and thus be able to lift a higher fluid column. When using known gas lift operation, the gas is able to reach a certain point also called the gas lift point. When using a gaseous liquid, the liquid is able to displace the fluid at a lower depth than when using pure gas. Some wells have such a low reservoir pressure that known gas lifts cannot get such wells to produce or increase the flow rate sufficiently; however when using gaseous liquid as artificial lifting fluid these low pressure wells can be productive again.

[0037] By fluid or well fluid is meant any kind of fluid that may be present in oil or gas wells downhole, such as natural gas, oil, oil mud, crude oil, water, etc. By gas is meant any kind of gas composition present in a well, completion, or open hole, and by oil is meant any kind of oil composition, such as crude oil, an oil-containing fluid, etc. Gas, oil, and water fluids may thus all comprise other elements or substances than gas, oil, and/or water, respectively.

[0038] The production casing may have annular barriers for prodividing zone isolation. By an annular barrier is meant an annular barrier comprising a tubular metal part mounted as part of the well tubular metal structure and an expandable metal sleeve surrounding and connected to the tubular part defining an annular barrier space. The exapandable sleeve of the annular barrier may be an expandable metal sleeve.

[0039] By a casing is meant any kind of pipe, tubing, tubular, liner, string or similar well tubular metal structure used downhole in relation to oil or natural gas production.

[0040] Although the invention has been described in the above in connection with preferred embodiments of the invention, it will be evident for a person skilled in the art that several modifications are conceivable without departing from the invention as defined by the following claims.

Claims

1. An artificial lift method for reducing a hydro-static pressure of a fluid column (1) in a top part (2) of a well (3), the well comprises a casing (4) and a production tubing (5) having the fluid column and being arranged within the casing, the well further comprises a main barrier (6) between the casing and the production tubing creating an annular space (7) above the main barrier, the production tubing has at least one gas lift valve (8) arranged above the main barrier, the annular space is fluidly connected to a feeding inlet (9) arranged in the top of the well, comprising:

    - providing a liquid,
    - providing a gas,
    - mixing the gas into the liquid upstream of the feeding inlet for providing an gaseous liquid (10) having a first gas content,
    - introducing the gaseous liquid at a first pressure into the annular space via the feeding inlet,
    - displacing a fluid (11) in the annular space, and
    - reducing the hydro-static pressure in the fluid column by allowing the gaseous liquid to flow into the production tubing through the gas lift valve.

2. An artificial lift method according to claim 1, further comprising increasing the gas content of the gaseous liquid to a second gas content being higher than the first gas content by mixing more gas into the liquid upstream of the feeding inlet.

3. An artificial lift method according to claim 2, further comprising increasing the gas content of the gaseous liquid to a third gas content being higher than the second gas content by mixing more gas into the liquid upstream of the feeding inlet.

4. An artificial lift method according to any of the preceding claims, comprising decreasing the gas content of the gaseous liquid by mixing less gas into the liquid upstream of the feeding inlet.

5. An artificial lift method according to any of the preceding claims, comprising detecting the hydro-static pressure in the fluid column.

6. An artificial lift method according to any of the preceding claims, comprising introducing a gas into the annular space.

7. An artificial lift method according to any of the preceding claims, comprising increasing the pressure of the gaseous liquid to a second pressure higher than the first pressure.

8. An artificial lift method according to any of the preceding claims, comprising detecting the pressure and/or flow in the fluid column.

9. An artificial lift method according to any of the preceding claims, comprising detecting the content of

the fluid in the fluid column.

10. An artificial lift method according to any of the preceding claims, comprising introducing a tracer fluid into the liquid.

11. An artificial lift method according to any of the preceding claims, wherein the well is a subsea well having a reservoir pressure above 34 MPa (5.000 psi).

12. An artificial lift method according to any of the preceding claims, wherein the gas is carbon dioxide, natural gas, methane gas, nitrogen, or a mixture thereof.

13. An artificial lift method according to any of the preceding claims, wherein the liquid is seawater.

14. An artificial lift method according to any of the preceding claims, wherein the fluid column comprises hydrocarbon-containing fluid.

15. An artificial lift method according to any of the preceding claims, wherein more than one gas lift valve are arranged in the production tubing.

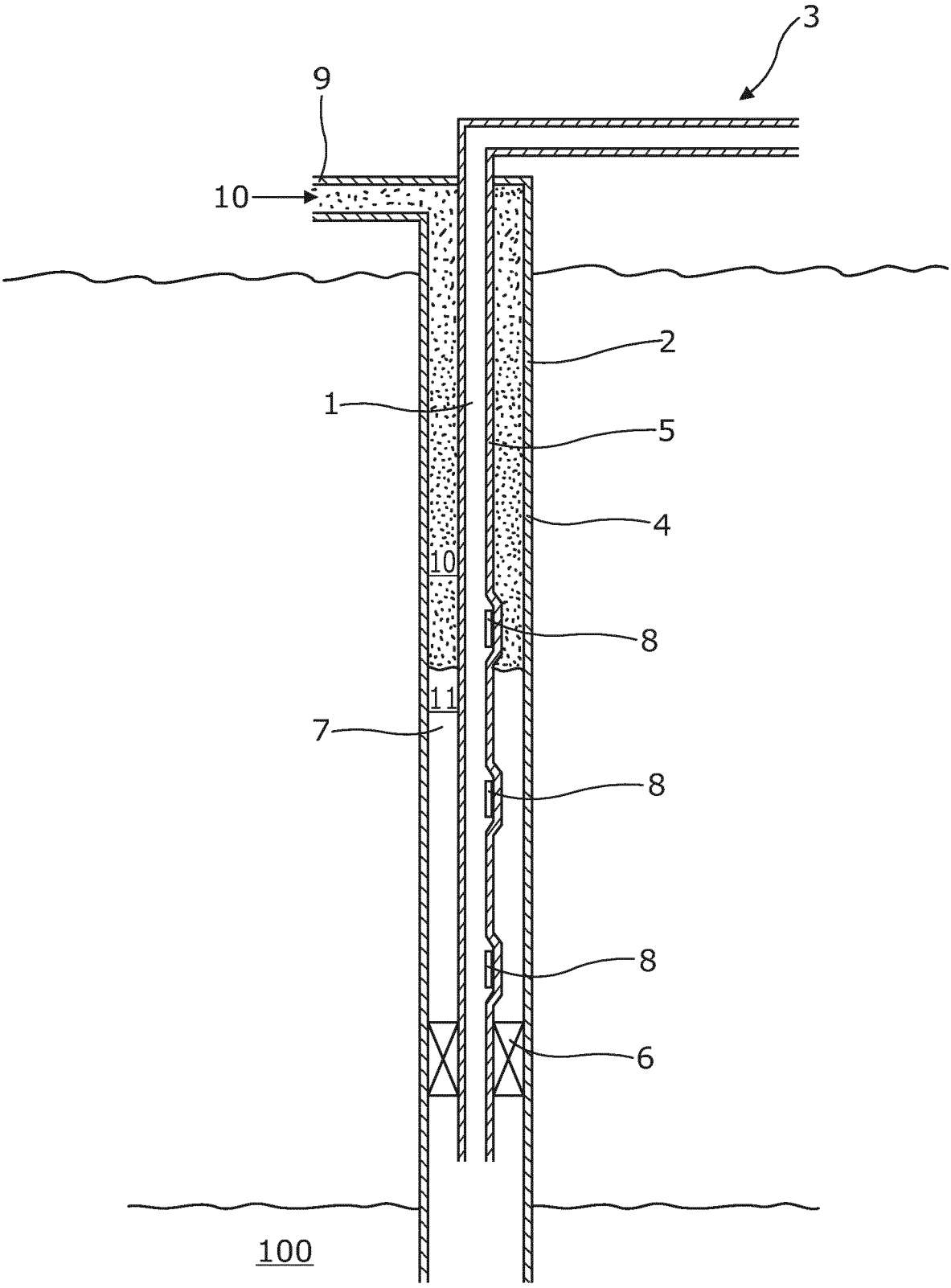

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 6376

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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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	18 September 2018	Morrish, Susan

CATEGORY OF CITED DOCUMENTS

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