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(54) SYSTEM AND METHOD FOR PRODUCING METHANE FROM A METHANE HYDRATE FORMATION

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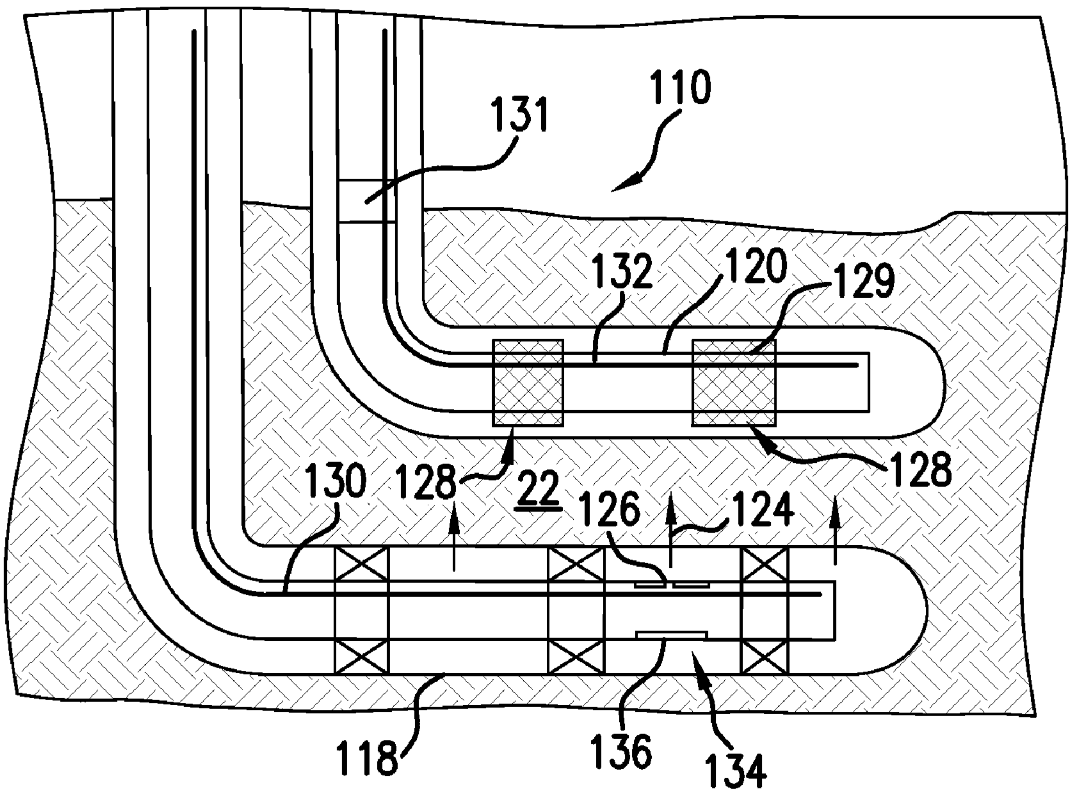
(57) **ABSTRACT**

A completion system includes a first borehole structure having a first section formed proximate to a volume of methane hydrate located at a subsurface location. A second borehole structure has a second section formed proximate to the volume of methane hydrate, the first section positioned deeper than the second section with respect to gravity. A first string is positioned in the first borehole structure and arranged to convey a heat-bearing fluid through the first string into contact with a volume of methane hydrate in order to liberate methane from the methane hydrate. A second string is positioned in the second borehole structure and arranged to produce the methane.



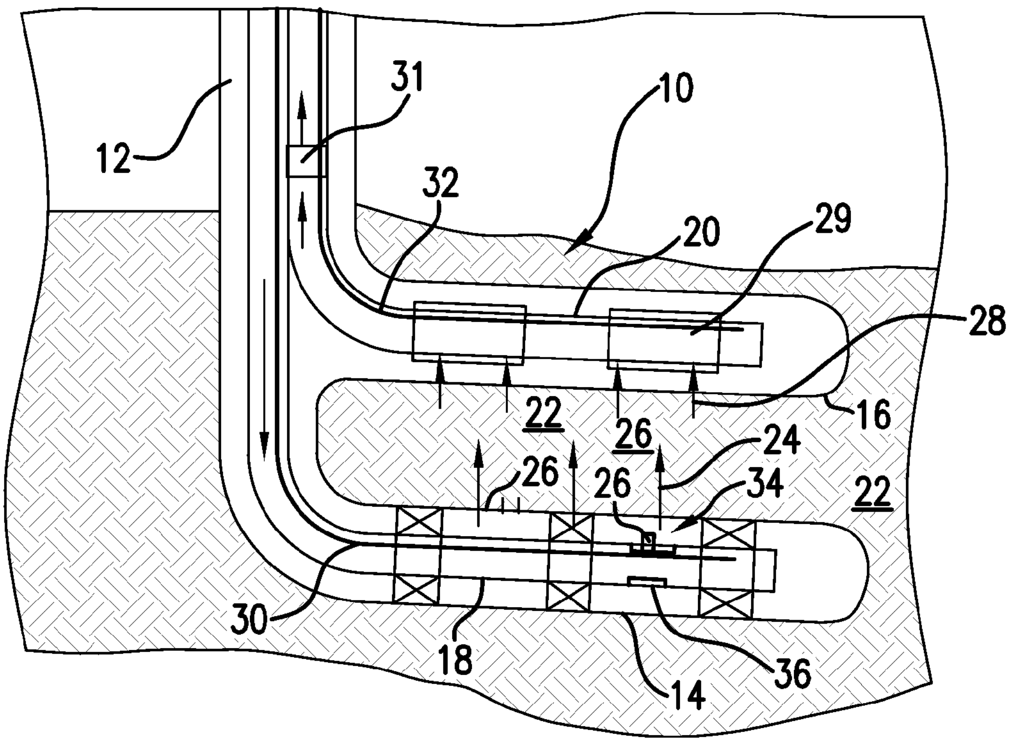

12
31
10
32
20
29
28
16
22
26
24
26
26
34
22
30
18
14
36

FIG. 1

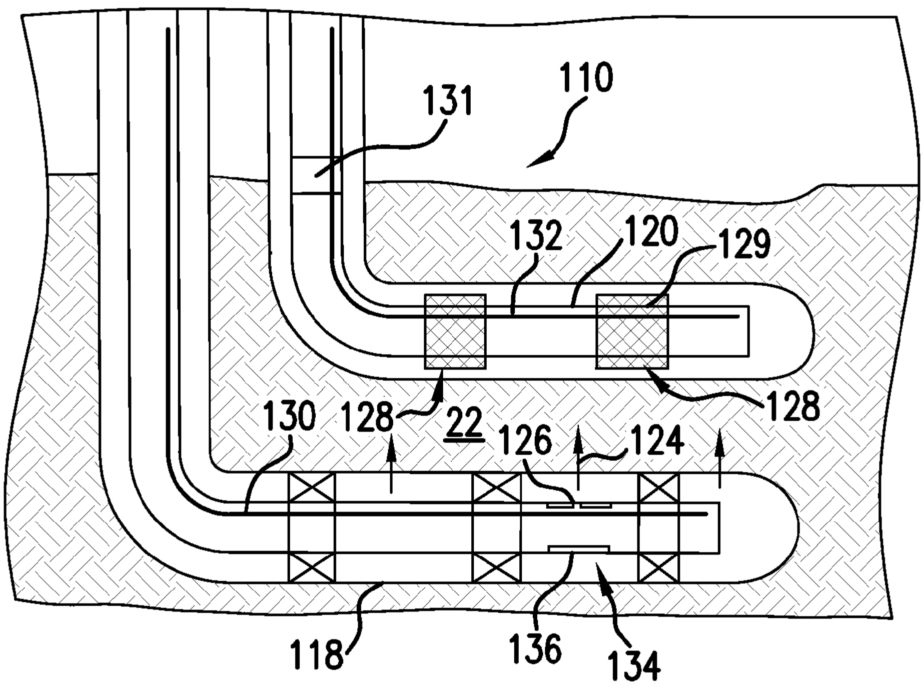

131
110
132
120
129
128
128
130
22
126
124
118
136
134

FIG. 2

SYSTEM AND METHOD FOR PRODUCING METHANE FROM A METHANE HYDRATE FORMATION

BACKGROUND

[0001] Methane hydrate is a clathrate compound in which water molecules freeze about methane molecules to form "cages" that trap the methane molecules therein. Methane hydrate deposits are believed to represent significant potential energy reserves for the energy industry but are difficult to recover. Due to the specific pressure and temperature requirements for the formation of methane hydrate, these deposits are primarily formed underground in subsea and arctic locations, frustrating their recovery. The industry eagerly receives new systems for producing methane from a methane hydrate formation.

SUMMARY

[0002] A completion system includes a first borehole structure having a first section formed proximate to a volume of methane hydrate located at a subsurface location. A second borehole structure has a second section formed proximate to the volume of methane hydrate, the first section positioned deeper than the second section with respect to gravity. A first string is positioned in the first borehole structure and arranged to convey a heat-bearing fluid through the first string into contact with a volume of methane hydrate in order to liberate methane from the methane hydrate. A second string is positioned in the second borehole structure and arranged to produce the methane.

[0003] A method for producing methane from methane hydrate includes conveying a heat bearing fluid to a formation containing methane hydrate through a first borehole section located deeper than a second borehole section relative to gravity, liberating methane from the methane hydrate, and receiving the methane in the second borehole section.

[0004] A method for producing methane hydrate includes controlling at least one parameter of methane hydrate stability so as to destabilize the methane hydrate, and liberating methane from the methane hydrate pursuant to the destabilization.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The following descriptions should not be considered limiting in any way. With reference to the accompanying drawings, like elements are numbered alike:

[0006] FIG. **1** is a cross-sectional view of a completion system for producing methane from a methane hydrate formation according to one embodiment disclosed herein; and

[0007] FIG. **2** is a cross-sectional view of a completion system for producing methane from a methane hydrate formation according to another embodiment disclosed herein.

DETAILED DESCRIPTION

[0008] A detailed description of one or more embodiments of the disclosed apparatus and method are presented herein by way of exemplification and not limitation with reference to the Figures.

[0009] A completion system **10** is shown in FIG. **1** for a multi-lateral borehole **12**. The borehole **12** includes a first lateral **14** and a second lateral **16** that in the illustration are highly deviated. It is to be understood that the laterals might be less deviated or could be provided by entirely separate wellbores in related embodiments (discussed further in connection with FIG. **2** hereunder). A first string **18** extends into the first lateral **14** and a second string **20** extends into the second lateral **16**. It is noted however, that while a single parent borehole is shown for the two laterals, the methodology for recovery described herein can utilize two independent proximately spaced boreholes with equal effect.

[0010] The laterals **14** and **16** are formed at least partially in, through, or otherwise proximate to a subsurface volume **22**, which at least partially comprises methane hydrate. It is to be appreciated that the volume **22** can include any number of other substances, e.g., sand, sediment, other gases, liquids, solids, etc. The volume **22** might be located at a subsea or arctic location, or any other location satisfying the unique temperature and pressure requirements that support the initial formation of methane hydrate as a deposit.

[0011] The first string **18** is arranged to convey a heat-bearing fluid into contact with the volume **22** or to simply convey heat to the volume **22** convectively, conductively or radiantly by supplying a heat generating device such as an electric heater (or similar) in the first string **18**. The terms "heat-bearing fluid" mean a fluid that is at a temperature greater than that of the methane hydrate, or a fluid carrying energy, e.g., chemical energy, that can be used to heat the volume **22**. For example, in one embodiment, the heat-bearing fluid is arranged to trigger or undergo an exothermic reaction, e.g., upon contact with another fluid or substance delivered or available downhole or by facilitating reaction between one or more substances delivered to the formation environment. In another embodiment, the heat-bearing fluid is steam that is produced by heating water. Heaters or heating elements may in some embodiments be included at surface, or within the string **18**. The heat-bearing fluid and/or the heat supplied from the heat-bearing fluid is indicated by a set of arrows **24** emanating from the first string **18**. In some embodiments, the first string **18** is equipped with ports **26**, perforations, or other openings for permitting the heat-bearing fluid to be pumped into contact with the volume **22** while in other embodiments, the string may only be arranged to conductively transmit the heat of the fluid rather than the fluid itself to the formation.

[0012] The application of heat to the volume **22** will cause ice in the volume **22** to melt, thereby enabling methane to be liberated from the cage of previously frozen water molecules. The liberated methane is indicated by a set of arrows and designated with the numeral **28**. By "liberated", it is meant that the methane is released from the methane hydrate in the volume **22**, is no longer trapped, contained, or restricted by the frozen water molecules of the methane hydrate, or otherwise is able to move in order for the methane to be produced. The second string **20** is accordingly arranged to receive the methane **28** that is liberated from the methane hydrate in the volume **22**. The second string **20** can be provided with ports, perforations, or other openings with or without screens **29** in order to permit entry of the methane **28** into the second string **20** for production of the methane **28**. In addition, in some embodiments, the second string will also include one or more ESPs **31** (Electric Submersible Pump) to assist in pumping the liberated fluid uphole and somewhat incidentally to produce some amount of heat that will help reduce the chances of a hydrate plug forming uphole of the formation.

[0013] In view of the above, it is to be appreciated that the functions of supplying heat and producing the methane **28** are divided between the strings **18** and **20**, with each of the strings

18 and 20 handling solely a designated task. In this way, the system 10 can be arranged to more efficiently control the parameters relevant to the formation of methane hydrate, e.g., temperature and pressure.

[0014] Utilizing two separate strings in the system 10 enables the first string 18, as illustrated, to be located deeper than and/or or below the second string 20 with respect to gravity. This arrangement promotes the efficient production of methane in a variety of ways. That is, for example, while the heat will generally act in all directions and form a pocket or envelop around the string 18, the positioning of the first string 18 deeper than the second string 20 will enable the natural tendency of heated fluids to rise, i.e., travel opposite to the direction of gravity, (e.g., by lowering the density of fluids as they are heated) to primarily direct the heat from the string 18 into the volume 22. It will however be understood that the second string 20 could be otherwise located providing that the envelope of heat and hence liberated methane will have access to the string 20 to promote production. In one embodiment, the first string 18 is arranged with openings on only the side directed toward the second string 20. Additionally, the relatively low density methane will tend to “rise above” water and other heavier molecules, causing the methane 28 to move opposite to the direction of gravity and into the string 20. It is also noted that sand, sediment, and other solid particles initially trapped in or with the volume 22 or surrounding ice will tend to move in the direction of gravity and settle about the string 18 hence being left behind instead of blocking the progress of the methane 28 into the string 20.

[0015] In the illustrated embodiment, the string 18 is arranged with an instrumentation line 30 and the string 20 is arranged with an instrumentation line 32. The instrumentation lines 30 and 32 are included to assist in controlling operation of the system 10 and can include fiber optic lines, chemical injection lines, hydraulic control lines, or other power and/or data communication lines. The lines 30 and 32 can include sensors therewith or be otherwise configured to sense or monitor one or more parameters, such as temperature and pressure, e.g., via fiber Bragg gratings or the like if optic fibers are used. In this way, the amount of heat conveyed via the string 18 can be tailored in response to changing downhole conditions. Also importantly, the conditions within the string 20 can be controlled in order to prevent methane hydrate from reforming and/or water molecules refreezing therein. That is, for example, the heat provided by the string 18 will keep the volume 22 and surrounding system components from freezing, but the methane 28 and other fluids produced by the string 20 may cool significantly while traveling through the string 20. For this reason, in some embodiments, the string 20 may be equipped with heaters along its length, and/or pumps or other mechanisms for depressurizing the string, as needed, to prevent the formation of methane hydrate or ice plugs within the string 20.

[0016] The system 10 also includes one or more valves 34 to assist in heating the volume 22 in a controlled manner. For example, each of the valves 34 can be arranged to selectively enable the heat-bearing fluid to flow therethrough. In one embodiment, the valves 34 each include a sleeve 36 that is shiftable to uncover one or more ports 26 to provide fluid communication to the volume 22. By controlling operation of the valves, the heat flow into the volume 22 can be influenced by injecting the heat-bearing fluid at only desired locations, setting the mass flow rate of heat-bearing fluid into the volume 22, etc.

[0017] It is to be appreciated that the laterals 14 and 16 represent one example of suitable borehole structures in which to install the first and second strings 18 and 22. For example, a system 110 is illustrated in FIG. 2 in which the borehole structures for containing the first and second strings 18 and 20 of the previous embodiment are formed as two separate boreholes designated with the numerals 118 and 120. It is to be understood that the system 110 can be used in essentially the same manner as described above with respect to the system 10, and can include any or all of the components described above, e.g., the instrumentation lines 130 and 132, valves 134, screens 129, etc. in each case the numerals have been modified by the addition of a one hundred series character in the front thereof

[0018] The system as described enables the method of producing Methane from Methane hydrate enabling conveying a heat bearing fluid to a formation containing methane hydrate through a first borehole section located deeper than a second borehole section relative to gravity; liberating methane from the methane hydrate; and receiving the methane in the second borehole section. But further, the system lends itself to controlling any one or more parameters of methane hydrate stability, any one of which being capable of causing a destabilizing effect that results in the liberation of Methane from the hydrate form. This includes not only the heat as described above but also other means for destabilizing methane hydrate such as chemistry of environment and/or pressure.

[0019] While the invention has been described with reference to an exemplary embodiment or embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

What is claimed is:

1. A completion system, comprising:

a first borehole structure having a first section formed proximate to a volume of methane hydrate located at a subsurface location;

a second borehole structure having a second section formed proximate to the volume of methane hydrate, the first section positioned deeper than the second section with respect to gravity;

a first string positioned in the first borehole structure and arranged to convey a heat-bearing fluid through the first string into contact with a volume of methane hydrate in order to liberate methane from the methane hydrate; and a second string positioned in the second borehole structure and arranged to produce the methane.

2. The system of claim **1**, wherein the first and second borehole structures comprise a first lateral and a second lateral of a multi-lateral borehole.

3. The system of claim **1**, wherein the first and second borehole structures comprise a first borehole and a second borehole separate from the first borehole.

4. The system of claim **1**, wherein the heat-bearing fluid includes steam.

5. The system of claim **1**, wherein the heat-bearing fluid comprises one or more components productive of an exothermic reaction.

6. The system of claim **1**, wherein the second string includes one or more screen assemblies that enable entry of the methane into the second string.

7. The system of claim **1**, further comprising one or more instrumentation lines disposed in the first string, the second string, or a combination including at least one of the foregoing.

8. The system of claim **7**, wherein the one or more instrumentation lines are arranged to enable one or more parameters related to formation of the methane hydrate to be sensed.

9. The system of claim **8**, wherein the one or more parameters include temperature, pressure, or a combination including at least one of the foregoing.

10. The system of claim **1**, wherein the system further comprises means to control at least one parameter of methane hydrate other than heat.

11. The system of claim **1**, wherein the first string comprises one or more valves for selectively controlling communication of the heat-bearing fluid with the volume.

12. The system of claim **1**, further comprising one or more Electric Submersible Pumps.

13. A method for producing methane from methane hydrate comprising:

conveying a heat bearing fluid to a formation containing methane hydrate through a first borehole section located deeper than a second borehole section relative to gravity;

liberating methane from the methane hydrate; and

receiving the methane in the second borehole section.

14. The method of claim **13** wherein the collecting includes selectively leaving behind constituents of the liberation of methane that are not methane.

15. The method of claim **14** wherein the selectively is by gravity.

16. The method of claim **13** wherein the method further includes heating the produced methane in other locations of the borehole than the section.

17. The method of claim **13** wherein the heat-bearing fluid includes steam.

18. The method of claim **13** wherein the heat-bearing fluid comprises components productive of an exothermic reaction.

19. A method for producing methane hydrate comprising:

controlling at least one parameter of methane hydrate stability so as to destabilize the methane hydrate;

liberating methane from the methane hydrate pursuant to the destabilization.

20. The method of claim **19** further comprising controlling one or more additional parameters of methane hydrate stability.

21. The method of claim **20** wherein the one or more additional parameters include chemistry of environment and pressure.

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