ABSTRACT

A method for controlling subsidence in wells completed through permafrost by contacting the permafrost adjacent the well bore with a hydrate forming fluid, thereby forming solid hydrates as the permafrost melts.

10 Claims, 1 Drawing Figure
1
SUBSIDENCE CONTROL PROCESS FOR WELLS PENERATING PERMAFROST

FIELD OF THE INVENTION

This invention relates to a method for controlling subsidence of wells penetrating permafrost. This invention further relates to a method for controlling subsidence of wells penetrating permafrost by contacting the permafrost adjacent said wells with a hydrate forming fluid, thereby forming solid hydrates as the permafrost melts.

PRIOR ART

As is well known, there have recently been discovered in many parts of the world petroleum reserves in areas which are covered with permafrost. Numerous new problems in drilling wells through the permafrost zones and recovering these petroleum reserves have been encountered. Many of these problems result from the unique nature of permafrost which is primarily frozen soil. As is well known, the permafrost remains frozen the year round and is often frozen to considerable depths. Problems have been encountered when oil is produced from oil bearing formations beneath the permafrost, as typically the oil produced is warmer than the melting point of the permafrost, and, as the oil is produced, the permafrost adjacent the well bore melts and ceases to provide support for the well bore casing and the like. As a result, the casing tends to buckle, distort, and otherwise fail to perform its assigned function, resulting in many difficulties in the production of the oil. Such problems are also encountered to a lesser degree in the drilling and completion of such wells. As a result, many attempts have been made to stabilize the permafrost during drilling and production from wells penetrating permafrost zones.

One such attempt is the use of large concrete aprons surrounding the well bore. As will be obvious, a certain amount of stability is imparted by this method since the concrete apron rests upon a large area of the permafrost and substantial melting must occur over a wide area before the concrete apron shifts. No such limitations apply to the well bore casing, however, and as the permafrost adjacent the well bore casing melts, the casing is free to shift, buckle, and the like, beneath the concrete apron.

Another method consists primarily of an attempt to insulate the well casing from the oil carrying pipe, thus preventing the transfer of heat from the oil to the permafrost. Such methods have enjoyed some success, but insulation does not prevent the transfer of heat but merely slows the transfer of heat, and, as a net result, the inevitable has merely been postponed and, after continued production from the well, the permafrost melts and instability in the permafrost zone occurs.

A third method has been an attempt to refrigerate the well bore casings. Of course, the refrigerating fluid must be continually circulated and cooled, and, as a result, considerable extra equipment is required. In addition, the likelihood of the permafrost melting during equipment shutdowns, break downs, and the like, cannot be totally disregarded.

In some instances, the foregoing methods have been combined; however, each combination suffers some of the disadvantages of the methods combined, and, as a result, the search has continued for an inexpensive and reliable method for controlling subsidence in wells penetrating permafrost.

OBJECTS OF THE INVENTION

It is an objective of the present invention to provide a simple and reliable method for controlling subsidence in wells penetrating permafrost zones.

SUMMARY OF THE INVENTION

It has now been found that the object of the present invention is achieved in a process for controlling subsidence in well bores penetrating a permafrost region comprising contacting the permafrost adjacent the well bore with a hydrate forming fluid so that solid hydrates having a melting point above that of the ice in the permafrost are formed as the permafrost melts.

BRIEF DESCRIPTION OF THE DRAWING

The drawing discloses an embodiment of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

The FIGURE illustrates one embodiment of the present invention. In the FIGURE. a well bore 14 penetrates an overburden 12 and an oil bearing formation 11. The overburden consists in part of a permafrost layer 13. The well bore comprises a larger cased portion 16 and a smaller cased portion 17. An oil recovery line 18 conveys oil from the oil bearing formation to the surface. It will be noted that cement 21 has been used to fill the space between the well bore casings and the well bore diameter. An inner casing 22 has been positioned inside the larger portion of the well bore casing. A second inner casing 23 also has been positioned inside the larger portion of the well bore casing as shown. The hydrate forming fluid is injected through injection line 24 and flows downwardly next to the portion of the casing adjacent the permafrost layer, beneath the lower end of the second inner casing and then upwardly and out through recovery line 25. A series of perforations 27 are positioned in a portion of the casing adjacent the permafrost layer so that the hydrate forming fluid is in contact with the permafrost zone and the overburden formation immediately beneath the permafrost zone. The maintenance of the hydrate forming fluid in contact with the permafrost zone results in the formation of solid hydrates as the permafrost melts. The permafrost will have a greater tendency to melt near the bottom of the permafrost zone and a typical configuration of a hydrate zone formed, 28, is shown. In the practice of the present invention, the well would be drilled and finished as shown. The production of oil typically involves the movement of warm fluids through the oil recovery line to the surface, thus resulting in melting the permafrost layer. The melting of the permafrost layer results in buckling of the well casing and numerous other difficulties associated with the melting of the permafrost zone. The embodiment of the present invention shown allows the use of refrigeration as well as the use of the hydrate forming fluid to form solid hydrates as the permafrost zone melts. In particular, the hydrate forming fluid can be cooled prior to injection through injection line 24 so that refrigeration is used to keep the outer casing cool, and any permafrost which melts is converted to a solid hydrate by the presence of a hydrate forming fluid.
Of course, many variations and modifications of the present invention are possible, and, for instance, the second inner casing could be omitted and the hydrates merely kept in contact with the permafrost zone. In this embodiment of the invention, no real attempt at refrigeration is made, and the permafrost is allowed to melt and convert to the solid hydrate. As noted, many variations and modifications of the present invention are possible and may appear obvious or desirable to those skilled in the art. Such methods are suitable so long as the hydrating forming fluid is maintained continuously or intermittently in contact with the permafrost zone.

It is readily seen that subsidence of the permafrost layer is effectively prevented since as the water melts, solid hydrates are formed which have a higher melting point than the water. Thus, the permafrost zone adjacent the well bore may be maintained in a solid state, thus continuing to provide support and stability for the well bore casing during oil production.

Hydrate forming fluids suitable for use in the process of the present invention are those fluids which form solid hydrates at temperatures greater than 32°F and preferably greater than about 40°F. Very desirable hydrate forming fluids are those which form solid hydrates at temperatures up to about 85°F and pressures from about 100 psi to about 900 psi. Some examples of suitable hydrate forming materials are fluids and mixtures of fluids selected from the group consisting of: methane, ethane, propane, isobutane, n-butane, carbon dioxide, acetylene, ethylene, chlorine, sulfur dioxide, hydrogen sulfide, methyl chloride, bromine, cyclopropane, 1,1-dichloroethane, methyl fluoride, chlorodifluoromethane, chlorofluorocarbons, methyl bromide, trichlorofluoromethane, dichlorodifluoromethane, 1,1-dichloro-1-fluoroethane, dichlorotrifluoromethane, mixtures of natural gases having specific gravities up to about 1.0, and the like. Preferred hydrate forming fluids are fluids and mixtures of fluids selected from the group consisting of: methane, ethane, propane, isobutane, n-butane, carbon dioxide, dichlorodifluoromethane, and mixtures of natural gases having specific gravities up to about 1.0. Particularly preferred hydrate forming fluids are mixtures of natural gases having specific gravities up to about 1.0. These mixtures are preferred because of their ready availability and their desirable hydrate forming properties. The hydrate forming properties of such gases and mixtures of gases are shown in the Handbook of Natural Gas Engineering, pages 209 to 213.

The natural gas mixtures, particularly those mixtures are those having a specific gravity from about 0.6 to about 0.9. As will be obvious to those skilled in the art, the permafrost adjacent the well bore may be contacted with the hydrate forming fluid by a variety of methods. For instance, the hydrate forming fluid may be injected intermittently or preferably continuously maintained in contact with the permafrost adjacent the well bore. The hydrate forming fluid may be used in conjunction with known methods for maintaining the permafrost zone in a frozen condition, such as insulaton and refrigeration. Many such variations and modifications are possible within the scope of the present invention since the essence of the present invention lies in the discovery that the permafrost zone adjacent well bores penetrating permafrost may be maintained in a solid condition by contacting the permafrost with a hydrate forming fluid so that when the ice in the permafrost zone melts, the water is immediately converted to solid hydrates, thus maintaining the permafrost zone in a solid state. It is believed that many variations and modifications within the scope of the present invention may be considered obvious or desirable to those skilled in the art upon a review of the foregoing description of the preferred embodiments and the following example.

Example

As oil at a 190°F flows from a production zone, heat will be transferred from the oil to the cooler formations (permafrost) surrounding the well. At the base of the permafrost, the soil is frozen and has a temperature equal to its melting point. At shallower depths the permafrost exists at temperatures below its melting point. Therefore, the first melting of the permafrost due to heat losses from the oil will occur at the permafrost base. A mixture of 28.8 mole percent propane and 71.2 mole percent methane kept in contact with this permafrost at a pressure of 120 psia will form a solid hydrate with liquid water from the melting permafrost. At this pressure the hydrate will not decompose until its temperature exceeds 45°F. At a surface pressure of 14.7 psia and a hydrostatic pressure gradient of 0.433 psi/ft, the pressure would be 120 psia at a depth of 243 feet. By increasing the pressure of the gas mixture to 170 psi, it is possible to maintain a solid hydrate at temperatures up to 50°F. The normal hydrostatic pressure would be 170 psi at a depth of 358 feet.

Other hydrate forming materials can be selected for use if higher temperatures are desired. For instance, ethane at 400 psia will form solid hydrates at temperatures up to 56°F. Increasing the gravity of natural gas will result in higher temperatures for hydrate formation. Pure methane at 500 psia will form a solid hydrate at 37°F or less. A 0.6 gravity gas will form hydrates at 51°F or less and 500 psia. A 0.9 gravity gas will form hydrates at 60°F or less and 500 psia. This pressure would correspond to a depth of 1,120 feet under normal hydrostatic gradient. Increasing the pressure up to a critical value for the material results in hydrate formation at higher temperatures as shown above with the methane/propane mixture. With a permafrost depth of 2,000 feet, the normal hydrostatic pressure will be 881 psi. Methane will form solid hydrates at this pressure and temperature up to 47°F.

It is noted that in general hydrate formation occurs at higher temperatures as pressure is increased. In most instances the higher temperatures will be encountered at the lower portion of the permafrost zone. The hydrate forming fluid is, of course, under greater pressure in the lower portion of the permafrost zone due to the pressure gradient of the fluid. It is thus seen that the formation and maintenance of hydrates is ideally suited to maintaining the permafrost zone adjacent the well bore in a solid state.

In the practice of the present invention wherein high pressures are used in the formation of the hydrates, it will be found desirable in some instances that the well casing not be perforated in the upper portion of the permafrost zone since the surface temperatures would tend to maintain the permafrost in a frozen condition in the upper portions of the permafrost layer, and further, since the pressures applied to the hydrate forming fluid may tend to result in the escape of portions of the hydrate forming fluid when the upper portions of the
casing are perforated. Such variations are well within the skill of those skilled in the art and need not be discussed further, since as has been shown, maintaining a hydrate forming fluid in contact with the permafrost zone adjacent the well bore affords a simple and reliable method for preventing and controlling well bore subsidence in well bores penetrating permafrost zones.

Having thus described the invention, I claim:

1. A process for controlling subsidence in well bore penetrating a permafrost region comprising contacting the permafrost adjacent the well bore with a hydrate forming fluid so that solid hydrates having a melting point above that of the ice in the permafrost are formed as the permafrost melts.

2. The process of claim 1 wherein said hydrate forming fluid is maintained substantially continuously in contact with said permafrost.

3. The process of claim 1 wherein said hydrate forming fluid forms stable hydrates at temperatures above about 40°F.

4. The process of claim 1 wherein said hydrate forming fluid forms stable hydrates at temperatures up to about 85°F.

5. The process of claim 1 wherein said hydrate forming fluid is a fluid or mixture of fluids selected from the group consisting of: methane, ethane, propane, isobutane, n-butane, carbon dioxide, acetylene, ethylene, chlorine, sulfur dioxide, hydrogen sulfide, methyl chloride, bromine, cyclopentane, 1,1-dichloroethane, methyl fluoride, chlorodifluoromethane, chloro-fluoromethane, methylbromide, trichlorofluoromethane, dichlorodifluoromethane, 1,1-dichloro-1-fluoroethane, and mixtures of natural gases having specific gravities up to about 1.0.

6. The process of claim 5 wherein said hydrate forming fluid is selected from fluids and mixtures of fluids selected from the group consisting of: methane, ethane, propane, isobutane, carbon dioxide, dichlorodifluoromethane, and mixtures of natural gases having specific gravities up to about 1.0.

7. The process of claim 6 wherein said hydrate forming fluid is a natural gas having a specific gravity from about 0.6 to about 0.9.

8. The process of claim 6 wherein said hydrate forming fluid is maintained in contact with said permafrost by injecting said hydrate forming fluid into a well bore casing having passageways in a portion of the casing adjacent to permafrost.

9. The process of claim 1 wherein a mixture comprising 28.8 mole percent propane and 71.2 mole percent methane is maintained in contact with said permafrost at a temperature lower than about 45°F and a pressure of about 120 psia.

10. The process of claim 8 wherein said hydrate forming fluid is also used as a refrigerant to cool the outer well bore casing.

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