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OIL RECOVERY USING STEAM

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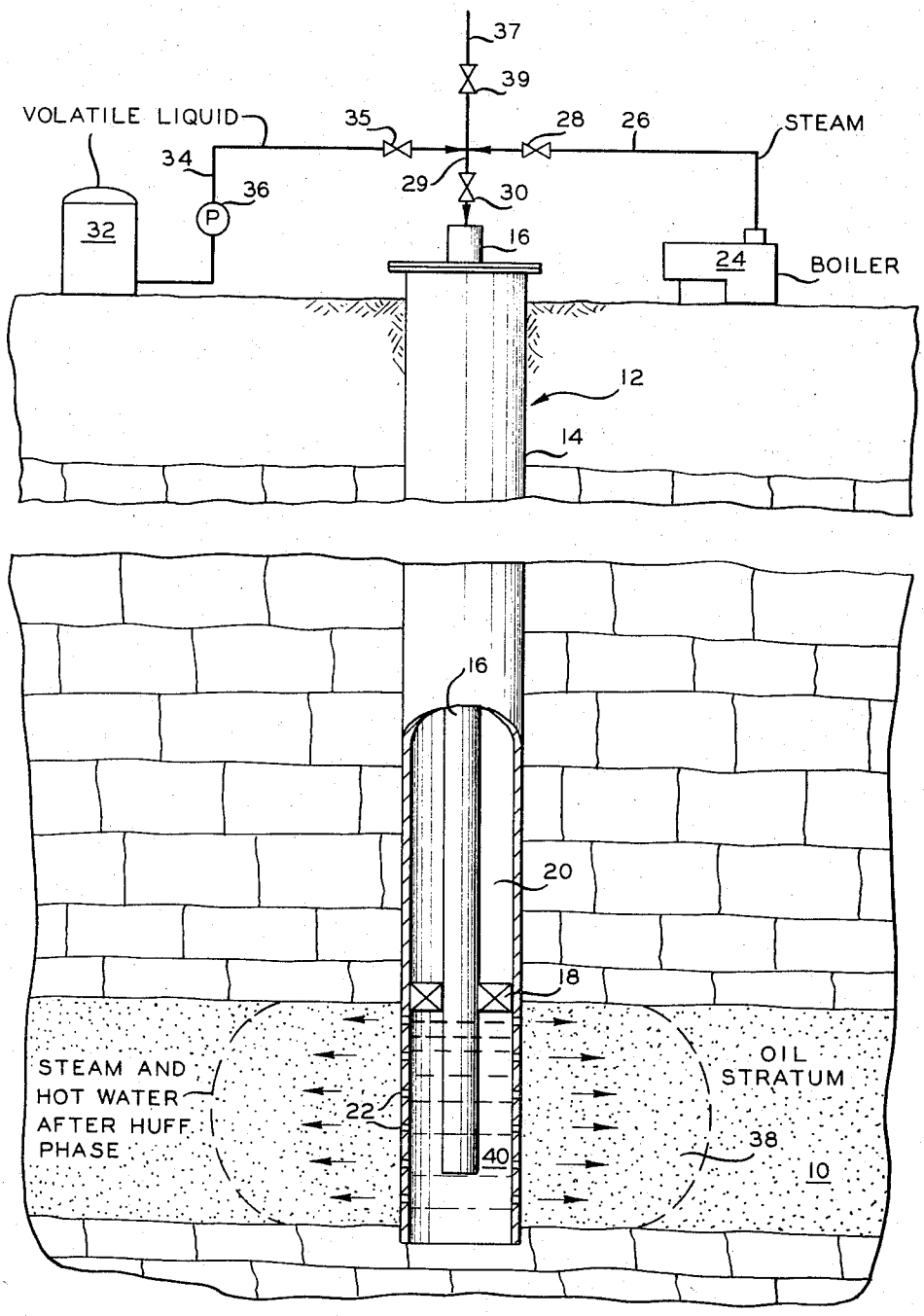

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OIL RECOVERY USING STEAM

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This invention relates to a process for recovering oil from an oil-bearing stratum utilizing steam injection.

In the huff and puff method of steam stimulation for oil wells, there is a soaking period during which heat is transferred by conduction from the steam invaded area deeper into the stratum surrounding the injection well. In the Morichal Field in Venezuela, which contains a heavy viscous crude oil, the normal steam injection period is about 21 days, and this is followed by a soak period of about six days after which the well is put on flow or pump. These injection and soak periods will vary substantially, depending upon the characteristics of the oil stratum in which the huff and puff steam method is applied. During the soaking period the steam contained in the steam invaded area condenses. This causes a flow of fluids from the stratum toward the steam zone, thereby decreasing the rate at which heat flows by conduction into the stratum away from the injection well. During the soaking period the well bore remains very hot and in the event it is necessary to service the well, it must first be "killed" with water to lower its temperature at a considerable loss of thermal energy.

The instant invention provides a simple procedure for minimizing both of the foregoing problems.

Accordingly, the principal object of the invention is to provide an improved huff aand puff method of producing oil from an oil stratum using steam as the heat stimulation medium. Another object is to provide a huff and puff steam stimulation method which prevents flow of fluids toward the injection well during the soak period. A further object of the invention is to provide a steam injection huff and puff method for oil recovery which substantially decreases the downhole temperature during the soaking period without susbtantial loss of thermal energy. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

In accordance with the invention, a volatile liquid is injected into the injection well in a huff and puff steam operation during the soaking period, whereby the volatile liquid is volatilized so as to cool the well bore downhole and create pressure in the surrounding stratum which maintains the pressure built up by the steam injection as steam condenses in the steam invaded area during the soaking period. Thus, at the end of the steam injection period, a liquid more volatile than water is injected into the well so that the heat stored in the stratum adjacent the well vaporizes the injected liquid and creates additional pressure downhole to compensate for the loss of pressure due to steam condensation in the steam invaded area. This technique has the effect of pushing the steam zone deeper into the stratum than is the case without the injection of volatile liquid.

The volatile liquid injected subsequent to the steam injection comprises any non-deleterious liquid more volatile than water. Examples of volatile liquids having utility in the process are propane, butane, LP Gas, natural gasoline, and other hydrocarbons of high volatility. Liquids other than hydrocarbons such as alcohols are also effective in the process.

The rate of injection of the volatile liquid is controlled so as to maintain the pressure within the stratum adjacent the well bore at least as high, and preferably higher, than the stratum pressure in the end of the steam injection

phase of the operation. In one embodiment of the invention, propane or other highly volatile liquid is injected at a sufficient rate to maintain the well bore pressure slightly above that of the stratum to prevent flow of fluids toward the well during the soaking period. When the well is open to production after the soaking period during the puff stage, the propane or other injected liquid is produced and condensed above ground for re-use in the process.

It is also feasible to inject a mixture of propane, or other volatile liquid, and water in order to reduce the volume of volatile liquid required and the cost of the operation. The water is also volatilized and helps dissolve heavy oxidized products in the startum. In the first test of the huff and puff method in the Morichal Field, the well would not flow after the soak period because of deposits of oxidized hydrocarbons. After the well was placed on pump and the oxidized products immediately around the well removed, the well reached a maximum production level far in excess of that experienced prior to the steam injection. The amount of volatile liquid to be injected during the soak period will usually vary from about 5 barrels to 500 barrels, depending upon the characteristic of the stratum, the quantity of steam injection, the pressure built up in the stratum, the length of the huff period, etc.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is an elevation through a well penetrating a heavy crude oil stratum with equipment for performing the process of the invention.

Referring to the drawing, a stratum **10** is penetrated by a well **12** which is provided with a casing **14** and a tubing string **16**. A packer **18** is positioned around tubing **16** so as to seal off the annulus **20** and restrict the injected fluids to the stratum **10**. The casing **14** is provided with perforations **22** below packer **18**.

A boiler **24** is provided above ground and a steam line **26** containing a control valve **28** connects the boiler with tubing string **16** through line **29** and valve **30**. A volatile liquid supply tank **32** is connected by line **34** with line **29** and contains a valve **35** and a pump **36** for forcing volatile liquid into tubing string **16**. Production line **37** containing valve **39** connects with tubing string **16** for recovery of oil during the puff stage of the process.

In the huff and puff method, steam from boiler **24** is forced into the stratum through tube **16** for a substantial period of time so as to cause the steam to invade an annular section of the stratum **38** which may extend out a distance in the range of 5 to 20 feet or more, initially. Steam injection is terminated and volatile liquid is injected from tank **32** by the means shown in the drawing so as to provide a mass of liquid **40** downhole. Thus, liquid vaporizes and the vapor invades the stratum behind the steam, pushing the steam and heated zone deeper into the stratum. While the drawing illustrates the volatile liquid in liquid form downhole, the injection of volatile liquid may be controlled at a rate such that it is volatilized as fast as it is introduced downhole.

After a substantial soak period during which volatile liquid is vaporized to maintain the pressure in the stratum and prevent flow of fluids toward the well, the well is opened to flow whereby fluids, including oil made less viscous by the heating provided, flow into the well and are forced up tubing **16** and into production line **37** containing valve **39** from which the fluids pass to conventional recovery means not shown. It is also feasible to position a pump on tubing **16** in the event the pressure downhole is insufficient to produce the fluids at an adequate rate.

The huff phase (steam injection), the soak phase, and the puff phase (production phase) are repeated so as to extend the heated zone deeper into the stratum, opening

up more stratum to production and recovering more oil therefrom. The process of the invention may be effected around a plurality of wells in any desired well pattern, either simultaneously or consecutively, so as to open up the stratum within the well pattern to relatively high fluid flow rates so that a direct steam drive between wells can be effected, or either a direct or inverse in situ combustion drive can be utilized to produce further quantities of oil from the stratum.

During the huff phase of the process, steam, which may range in temperature from about 350 to 700° F. or higher, substantially heats the borehole wall from ground level down thru the tubing, annulus and casing, most of this heat is transferred to the stratum during injection of volatile liquid by vaporization of the liquid in the tubing and downhole area and movement thereof into the steam-invaded area of the stratum where at least a portion of the vapor condenses. Thus heat from the borehole and stratum immediately surrounding the borehole is cooled by vaporization of the injected liquid and the heat lost is delivered to the stratum more remote from the borehole and steam and hot condensate deeper into the stratum.

Generally, the longer the huff period and the higher the steam temperature, the larger the volume of volatile liquid can be injected effectively. Larger volumes of injected liquid promote more heat drive into the stratum.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for producing oil from a permeable oil stratum penetrated by a well which comprises the steps of:

(1) injecting steam into said stratum thru said well for a substantial period to heat said stratum and build up pressure therein;

(2) terminating the injection of steam and injecting into said stratum a liquid more volatile than water which is volatile at downhole temperature;

(3) maintaining said well closed in for a substantial soaking period so as to vaporize at least a substantial portion of the liquid injected in step 2 and drive heat deeper into said stratum from said well; and

(4) thereafter, opening said well to flow and producing oil therefrom.

2. The process of claim 1 wherein said liquid comprises low-boiling hydrocarbon.

3. The process of claim 2 wherein said hydrocarbon comprises essentially propane.

4. The process of claim 2 wherein said hydrocarbon comprises essentially butane.

5. The process of claim 2 wherein said hydrocarbon comprises essentially natural gasoline.

6. The process of claim 2 wherein said hydrocarbon comprises essentially LP gas.

7. The process of claim 1 wherein low-boiling hydrocarbon and water are injected in step 2.

8. A process for producing oil from a permeable stratum containing a viscous oil and penetrated by a well, which comprises the steps of:

(1) injecting steam at a temperature of at least 350° F. into said stratum thru said well for a substantial period so as to heat and pressurize said stratum;

(2) terminating steam injection and injecting low-boiling liquid hydrocarbon into said well so that said hydrocarbon is vaporized downhole and maintains pressure in said well, thereby preventing any substantial flow of fluids toward said well;

(3) terminating step 2 after a substantial period and opening said well to flow of fluids, thereby producing oil in said well; and

(4) recovering the fluids, including oil, from said well.

9. The process of claim 8 wherein injection in step 2 is controlled so as to maintain substantially the pressure existing in said stratum at the end of step 1.

10. The process of claim 8 wherein a hydrocarbon liquid of intermediate volatility is introduced for a substantial period in step (2) and a liquid hydrocarbon of high volatility is thereafter introduced for substantial period.

11. The process of claim 10 wherein the liquid of intermediate volatility is natural gasoline and that of high volatility is LP gas.

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