THERMAL SECONDARY RECOVERY

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ABSTRACT OF THE DISCLOSURE

A steam soak process for the recovery of crude oil wherein a producing formation is first heated with steam and then produced. The process includes the adding of caustic or detergents to the steam to increase the affinity of the formation rock for water. When the steam condenses, the water held in the interstices and becomes immobilized. This reduces the water that is produced when the well is returned to production and increases the oil recovery.

BACKGROUND OF THE INVENTION

The present invention relates to secondary recovery processes and more particularly to an improvement in a steam soak recovery process. The term steam soak is used to refer to a recovery process in which a hydrocarbon-containing formation is heated by injecting steam into the formation. After a predetermined quantity of steam has been injected, the well is normally shut in and allowed to soak. The length of the soaking period is adjusted so that a substantial quantity of the latent heat of the steam is transferred to the formation to heat the hydrocarbons contained therein to reduce their viscosity and make them more mobile. After the soaking period, the formation hydrocarbons are produced to the well using a normal depletion reservoir drainage mechanism as for example, gravity drainage, or solution gas drive, and removal from the well by pumping or other normal production methods.

The steam used in a steam soak recovery method may be high-quality, substantially dry, steam or may be low-quality steam containing a considerable amount of water in a liquid phase. A steam soak process using a low-quality steam is more particularly described and claimed in U.S. Pat. No. 3,193,009. The steam may be injected into the hydrocarbon-containing formation for a few hours to several days. The length of time that the steam is injected is determined by the viscosity of the oil and the permeability and other formation characteristics that affect the efficient transfer of the latent heat of the steam to the hydrocarbons contained in the formation. After the soaking period, the well is placed back on production using conventional producing mechanisms normally of the depletion type of drive in combination with pumping or similar lift methods.

A more complete description of a steam soak process as applied to recovering viscous crude is available in an article by T. M. Doscher in the Oil and Gas Journal, for July 11, 1966, page 95. While the Doscher article describes the use of a steam soak process as applied to the recovery of viscous crude oils, the process can also be applied to increase the production of less viscous crude oils. The Doscher article also provides data for determining the length of time that steam should be injected as well as the length of time that the formation should soak before the well is placed back on production.

While the above process for steam soaking has been successful in improving the production from hydrocarbon-containing formations, it does have one serious problem. Since the process uses steam to heat the formation, considerable water is produced when the steam condenses. Thus, when the oil from the formation is subsequently produced, the water is also produced. The production of water is, of course, undesirable since it must be separated from the hydrocarbons before the hydrocarbons can be shipped in a pipeline or by other means. Thus, if the amount of water produced could be reduced, the economics of the process would be considerably improved.

SUMMARY OF THE INVENTION

The present invention solves the problem of excessive production of water by adding a chemical to the steam that will reduce the surface tension of the water. By reducing the surface tension of the water, the water will be trapped by the interstices of the formation rock and held in place and not produced when the well is returned to production. In addition to reducing the amount of water produced with the hydrocarbons, the trapping of the water in the interstices of the formation rock will also displace an equivalent amount of hydrocarbons from the formation.

Various types of chemicals may be used for reducing the surface tension, as for example, various caustic compounds or detergent compounds. Various chemicals capable of reducing or lowering the surface tension of water are well known to those skilled in the art and any chemical that is compatible with the formation can be used.

The process of the present invention will only work in particular types of formation, more particularly, formations having a hydrocarbon-containing sand whose natural wettability ranges from neutral to oil-wet. In addition, the formation in the vicinity of the well should be free of mobile water, so that the well does not produce water. Likewise, the producing mechanism for the well should be oil-expansion, solution gas drive or gravity drainage, and not a secondary recovery drive means, such as a water drive.

PREFERRED EMBODIMENT

As explained above, the present invention is applicable only to steam soak operations in which a producing formation is heated by injecting steam. After the steam is injected, the well is closed in and the formation allowed to soak. The well is closed in to permit both the sensible and latent heat of the steam to be transferred to the hydrocarbons contained in the formation. After a sufficient time, the well is placed back on production and produced by means of a conventional producing mechanism of the depletion type. For example, a solution gas drive or gravity drainage may be used to cause the oil to flow into the well from which it may be removed by pumping or other lift means.

In addition to the above limitations of the steam soak process, the invention is also limited to formations that are capable of oil production and having a natural wettability ranging from neutral to oil-wet. The invention will not operate where the formation has been subject to a secondary recovery employing water flood or where the initial primary production was the result of a water drive. In addition, the formation in the vicinity of the well is preferably free of mobile water so that the production of the well does not normally produce water.

When the above requirements are met, the process of this invention may be economically employed. The invention is best applied in the case of a steam soak process using a low-grade steam or at least a steam containing some liquid phase. This will permit the chemicals to be conveyed to the formation with the liquid phase. A process employing low-grade steam is described in the above-referenced patent. Chemicals that are capable of increas-
ing the water-holding capacity of an oil-bearing formation by altering the wettability of the formation are injected with the liquid phase of the steam. A substantially low concentration of the chemicals, as for example, approximately 4 milligrams of sodium hydroxide per liter of steam, is used. Suitable chemicals for use are the various caustic compounds such as sodium hydroxide, and non-ionic detergents or surfactants such as poly-glycol ethers or aryl-alkyl-sulfonates. Additional chemicals are known to those skilled in the secondary recovery art and have been used in various water flood processes to increase the scouring effect of the water as it is moved through the formation.

After the steam is injected and the well is shut in, a portion of the steam will condense and the treated water will increase the water wetness of the formation. This will increase the portion of the water that is held by the formation and prevent its production when the well is returned to production.

The invention is particularly useful in a steam soak process employing a one-well system producing a viscous crude, as explained above. In a one-well system, the invention has the following effects:

(1) Injecting the treated steam into a closed reservoir raises the oil production potential of the reservoir by retaining a portion of the water in the reservoir formation. The amount of water retained in the reservoir formation will at the same pressure displace an equivalent volume of crude from the reservoir. Thus, the production rate of the crude as a result of the injection will be above the pre-injection rate.

(2) The heat economy of the process will be improved using treated steam, since the condensed steam will be held in the formation. Thus, if the heated water is held in the formation, it will transfer an additional amount of heat to the crude in the formation and enhance the crude recovery.

While the above description has been related specifically to a preferred arrangement including a steam soak process and a one-well system, it may under certain limited conditions be applied to steam soak processes using multiple wells. In all cases the invention must be limited to formations that have a natural wettability ranging from neutral to oil-wet. Also, any formation that has been subject to a secondary recovery process employing a water flood drive is unsuitable for the practice of the present invention. Except for the above limitations, the invention can be applied to a multiple well recovery system. The amount of improvement will be proportional to the change towards water wetness achieved. The maximum capacity is achieved at maximum or total water wetness.

I claim as my invention:

1. A method of primary recovering essentially only liquid hydrocarbon from an underground earth formation free of having been subjected to any previous water drive oil recovery treatment and having a natural wettability ranging from neutral to oil-wet penetrated by well bore comprising:

   (a) adding to steam an effective amount of caustic to reduce the surface tension of water but insufficient to cause emulsification;
   (b) injecting the caustic containing steam into the formation;
   (c) closing the well to allow the formation to steam soak, and
   (d) placing the well on production to effect liquid hydrocarbon recovery by means selected from the group consisting of gravity drainage and solution gas drive.

2. The method of claim 1 wherein the caustic is NaOH and the amount used is approximately 4 mg./liter of steam.

3. The method of claim 2 wherein the hydrocarbon recovery is effected by a backflow producing technique.

References Cited

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