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RECOVERING OILS FROM FORMATIONS

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This invention relates to the recovery of oils from formations. In one of its aspects, the invention relates to the recovery of an oil from consolidated sandstone or other formations by a method involving the injection of steam and a solvent, the solvent being ordinarily largely in the vapor phase.

In the method of recovering heavy oils from tar sands or consolidated sandstone by injection of steam, a bank of oil builds up in a cold zone, restricting flow, causing high moving pressures. Thus, it is known, generally, to extract oil and similar material from shale, sand, or other bituminous material which is in its natural condition in the ground, by forcing superheated steam into a first well to produce heat radiation toward a second well and then operating the second well as a recovery well. In Patent 2,412,765, granted December 17, 1946 to E. Buddrus et al., there is described and claimed a method of preparing partially depleted oil-bearing formations for volatile hydrocarbon storage including the steps of injecting condensible hydrocarbon vapor into the partially depleted oil-bearing formation through an input well, permitting the injected vapor to condense substantially completely to a liquid within the pores of the formation, thereby warming and dissolving the oil to facilitate drainage of the oil into the input well bore and into adjacent well borer, and then producing the mixture of oil and fully condensed vapor from the input and adjacent well bores, etc. Referring especially to consolidated sandstone such as the Barton tar sands, I have now found that the injection of steam and a solvent vapor, for example, kerosene vapor, as described later herein, yields results which are superior to a marked extent over those which have been obtained in the prior art employing steam alone or a condensible hydrocarbon vapor as described in the above-mentioned Buddrus Patent 2,412,765, that is, for example, propane or butane. Thus, while the results obtained by following the modus operandi of the above-mentioned Buddrus patent to secure the objects thereof are considered extremely good, the findings according to the present invention, as applied to such formations as the Barton tar sands, indicate that the injection of steam together with a largely vaporized normally liquid hydrocarbon solvent will yield improved results.

It is an object of this invention to recover oils, especially heavy oils, from consolidated sandstone or other similar formations. It is another object of this invention to produce heavy oils from consolidated sandstone or other formations having the characteristics of the Barton tar sands. Other aspects, objects, and several advantages of the invention are apparent from this description and the appended claims.

According to the present invention, an oil or tar is recovered from an oil or tar-containing sand, such as a Barton tar sand, or consolidated sandstone or other formation, by injecting thereinto a mixture of steam and a hydrocarbon solvent, thereby lowering the viscosity of the tar or oil and permitting it to travel through the sand

more rapidly than heretofore possible by the injection of either steam or a condensible hydrocarbon, as described, even after the stream has cooled and its oil or tar has, therefore, also cooled, the modus operandi, according to the invention, in effect avoiding the building up of a bank of oil or tar in a cooled or cooler zone, the said build-up ordinarily restricting flow and, therefore, causing high-moving pressures.

Still, according to the invention, in its now preferred form, a sufficient quantity of steam or water vapor at a desired temperature is employed to carry into the formation largely in vaporous form, preferably entirely in vaporous form, the normally liquid hydrocarbon solvent which is employed. This means that, according to the invention, the steam will ordinarily be in substantial excess over the hydrocarbon solvent which is employed and ordinarily, the ratio of the steam to the hydrocarbon will be in excess of 3:1, preferably in excess of 4:1.

Normally liquid hydrocarbon solvents which can be used are those which, when admixed with the oil or tar to be produced, will reduce the viscosity of the combined mixture considerably below that of the tar in place. The steam facilitates mixing of the solvent, which ordinarily will have the characteristics which are possessed by such liquids as kerosene, gasoline, jet fuel, Stoddard solvent, benzene, xylene, toluene, etc.

One skilled in the art in possession of this disclosure will recognize that the heat which is imparted to the solvent, causing the same to assume the vapor state, not only facilitates the pumping of the combined mixture into the formation but also assists the solvent in penetrating into the formation and the oil or tar therein contained. Consideration of the factors involved upon condensation of the solvent and of the steam or water vapor will at once indicate to one skilled in the art in possession of this disclosure, that, according to the present invention, the modus operandi has been provided wherewith to admix the oil with a normally liquid hydrocarbon solvent which, however, is easily placed into the formation without ever having to attain high pressures in the formation which would be required to condense a normally vaporous solvent to derive its solvency benefit. Thus, sandstones near the surface of the ground, which will not contain higher pressures, can be produced according to the invention. Also, the use of steam permits the carrying of substantial quantities of heat into the formation from which some steam may escape without great loss as might be experienced if a high-pressure gas, such as methane, were employed.

The temperature of the steam and normally liquid hydrocarbon vapor is adjusted to carry a sufficient quantity of heat into the formation and to produce the formation. Ordinarily, the temperature of the vaporous mixture injected into the sand will be in excess of about 225° F. at approximately atmospheric pressure or slightly higher. With higher pressures, which, however, according to the invention, are still lower than some of those which have been previously employed as described, the temperatures employed will, of course, be higher. For example, pressures up to and even exceeding 500 pounds per square inch at temperatures up to 470° F., or higher, are within the scope of the present invention. Also, proportions of steam to hydrocarbon vapor up to as high as 2:1, or higher in some cases, can be employed. Thus, although the invention is not specifically limited to the specific ratios, temperatures, etc., which have been herein disclosed, the improved results which are obtained are now obtained within said ranges of conditions. Therefore, the said ranges of conditions are preeminently preferred at this time.

The specific method selected for injecting the sandstone or other formation, according to the invention,

will be one especially adapted to the particular formation to be produced. In the event of a fairly deep formation being produced, there will be at least one bore through which the vapor mixture will be pumped into the formation and at least one producing bore or well through which the material of lower viscosity will be produced. However, in the event a bank is being worked and can be approached from a side, it is within the scope of the invention to inject at one or more places substantially at the bottom of or below the sand, thus making use of the floating capacity or displacing capacity of the condensed steam, in the form of water, to assist in forcing the oil upwardly into wells drilled down to the top of the said formation, especially in the event that there is present no real or usable natural gas pressure in the formation. Of course, it is contemplated within the scope of the present invention to upwardly produce such a formation by drilling deeper vapor supply bore holes from the surface, thus to cause the lower viscosity material to be produced in an upwardly direction toward producing bore holes or wells.

In an actual operation according to the modus operandi of the present invention, water and kerosene in ratio of 4:1 were heated together and the vapors were injected into three different portions of Barton tar sand. The porosity of these portions have been determined to be approximately 25 percent. The air permeability had been determined to be approximately 100 md. Initial tar saturation was approximately 50–55 percent of the pore space.

At the start of the injection process, the mixture of steam and kerosene was injected at 25 p. s. i. vapor pressure. After producing one pore volume, i. e., a volume equal to the volume of the pore space within the sample, of fluid, tar, kerosene and water, the injection of the kerosene with the steam was discontinued. The remainder of the tar production was by steam injection alone. This sequence was followed to establish the liquid permeability and then recover the kerosene plus additional tar.

At the completion of the extractions, measurements of the residual tar saturations were made. The results are as follows:

Sample No.	Residual tar sat., percent
1	3.1
2	9.1
6	9.7

The air permeability of the samples after extraction was approximately 1000 md.

A method for determining air permeabiliy is given in U. S. Patent 2,633,015 issued to W. L. Morris.

In the above tests, sample cores 1" in diameter by 4" long were cemented with neat Portland cement into a metal pipe wrapped with asbestos. A vapor line was connected to one end of the cylinder and an oil recovery line was connected to the other end of the cylinder through caps. Vapors were thus forced through the core sample from one end to the other. The kerosene in the vapor tends to distill tar ahead of the heat wave, thus freeing a path for the flow of tar.

The pressure was adjusted in the tests to simulate actual conditions. About one pound per foot of overburden depth is employed. It will be clear to one skilled in the art that steam and hydrocarbon vapor mixture temperature will be a function of pressure. At all times, the temperature is selected so that substantially vaporous mixture is forced into the sandstone. Usually 10 to 25 percent by volume of hydrocarbon, corresponding to about 90 to 75 percent steam, is employed.

The use of steam, alone, is not possible because steam will meet the tar and substantially "plug" the sand. No oil could be recovered. On the other hand, it is noted that kerosene vapors do not carry sufficient heat and, of course, would be prohibitively expensive to use and/or to recover. Usually, the temperature of the steam and hydrocarbon vapor mixture will be in the approximate range 225–500° F., and the mixture is pumped at a pressure of at least about 20 p. s. i. g.

The sands treated in the foregoing description were found in Barton County, Missouri, and are more specifically known as Clear Creek sand.

As an important feature of the present invention, the injected steam and hydrocarbon or other solvent vapors are injected into a place in the formation which is intermediate the upper and lower levels in order that heat loss to the over- and underburdens will be minimized. The injection can be into a hydraulic fracture, say, in a middle or mid-portion of the formation. Any formation or part thereof can be hydraulically fractured prior to injection with the said vapors.

Although in the examples given, steam was used, alone, following the injection of the vapor mixture, it is clear that such injection need not follow in the field use of the invention. The steam injection described was employed to permit determination of core permeability.

Reasonable variation and modification are possible within the scope of the foregoing disclosure and the appended claims to the invention, the essence of which is that it has been found that a mixture of steam and a normally liquid hydrocarbon vapor are employed to facilitate production of oil or tar from a consolidated sandstone or other formation, particularly from a Barton tar sand.

I claim:

1. The production of tar from Barton tar sand which comprises forming a mixture of steam and kerosene, in which the steam is in excess over the kerosene, by volume of vapors, and then injecting the mixture of vapors thus obtained at a pressure of at least about 20 pounds per square inch gage and at a temperature in the approximate range 225–500° F. into the sand and then producing tar from said sand by passing said mixture through a substantial portion of said sand.

2. A method of producing a heavy oil from a consolidated sandstone formation which comprises forming a mixture of steam and a normally liquid hydrocarbon vapor, injecting said mixture at a pressure of at least about 20 pounds per square inch gage and at a temperature in the approximate range 225–500° F. into the formation and then producing oil from the injected formation by passing said mixture through a substantial portion of said formation.

3. The production of an oil-bearing formation which comprises preparing a mixture of steam and a normally liquid hydrocarbon vapor at a pressure of at least about 20 pounds per square inch gage into the formation, the ratio of steam to hydrocarbon vapor being at least about 2:1, injecting said mixture at a temperature in the approximate range 225–500° F. into the formation in a quantity sufficient to cause lowering of the viscosity of oil in said formation, and producing the oil from said formation which has been so injected.

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