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Wang et al.

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[54] **PRODUCING OIL FROM TAR SAND**

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[52] **U.S. Cl.** **166/263,** 166/272
[51] **Int. Cl.** **E21b 43/00,** E21b 43/24
[58] **Field of Search** 166/263, 272, 303

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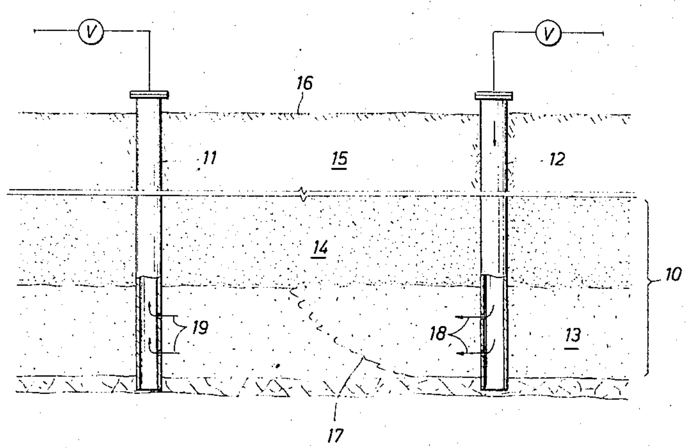
[57] **ABSTRACT**

In a tar sand formation in which a relatively water-impermeable zone overlies a water-permeable zone, tar is recovered by injecting steam into the permeable zone to establish a hot, water-permeable channel between at least one production and at least one injection well, said channel preferably having a tar mobility of at least 15 md/cp; continuing steam injection at a rate sufficient to maintain mobility of the tar in the channel at 15 md/cp and increase the tar mobility in the bulk of the formation to about 15 md/cp, preferably while at about the same time restricting production of fluids from the production well; decreasing the pressure in the formation by increasing production from the production well; and recovering the bitumen from the fluids produced.

20 Claims, 3 Drawing Figures



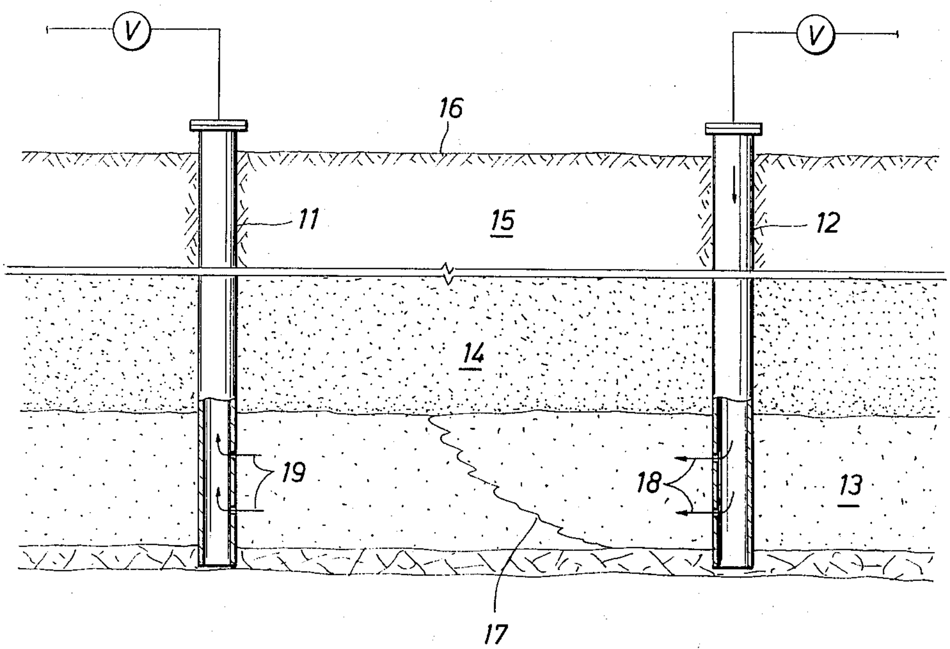


FIG. 1

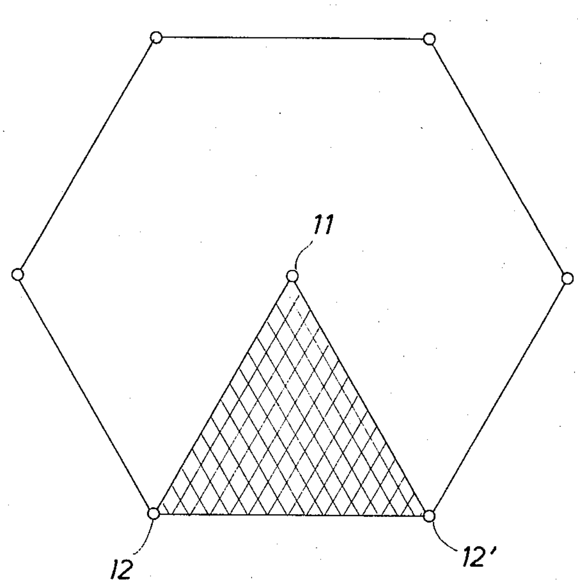
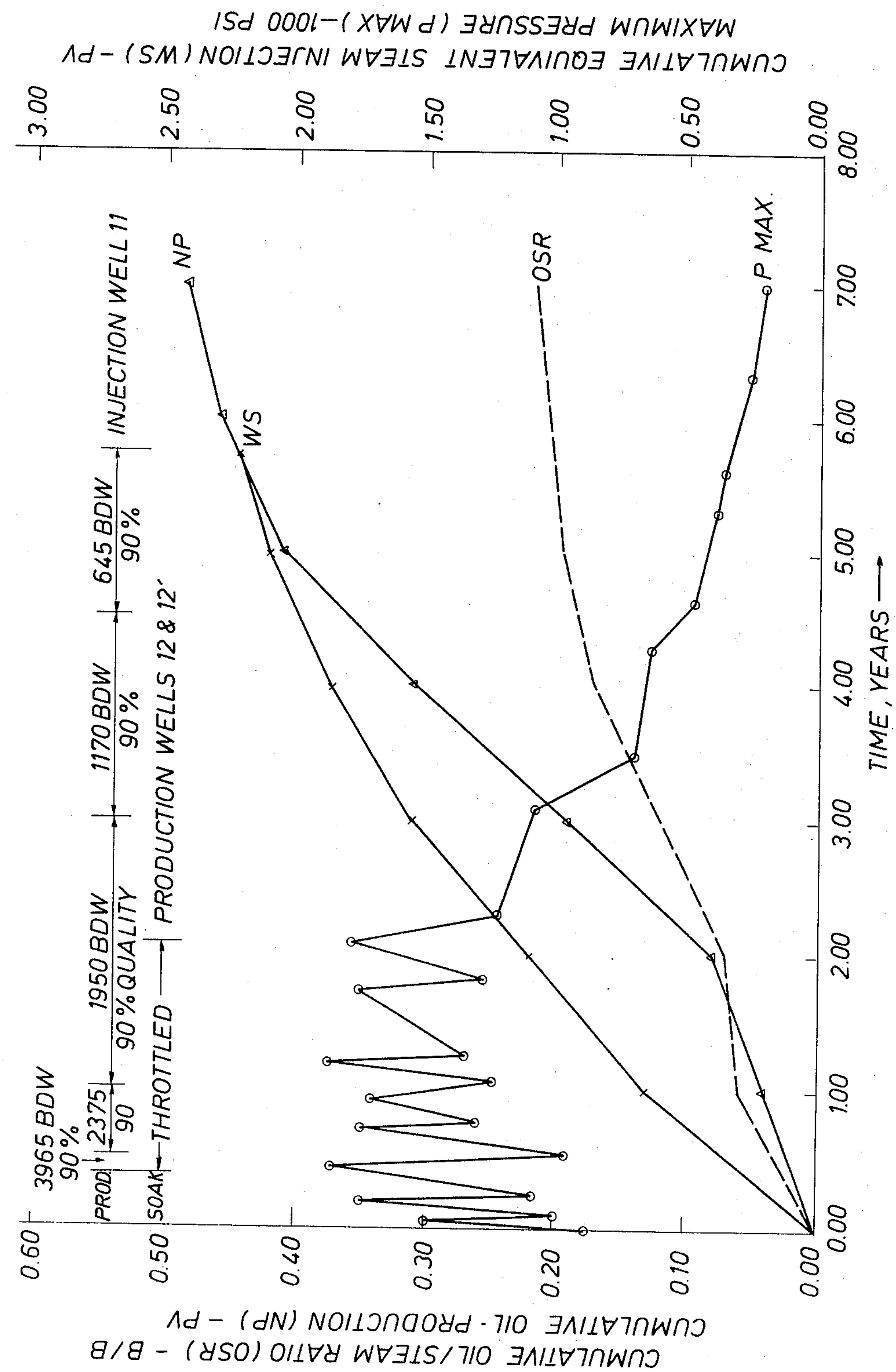


FIG. 2

FIG. 3

EMBODIMENT I - PHYSICAL MODEL
PRODUCTION INJECTION PERFORMANCE



PRODUCING OIL FROM TAR SAND

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a process for producing bituminous fluid from bituminous sand formations.

2. Prior Art

In view of the increasing rate of energy usage in the world today, it is becoming clear that methods must be found to recover energy values from all available fossil sources of fuel, especially those heretofore relatively undeveloped unconventional sources such as tar sands. It has been known for many years that large deposits of tar sands exist in the world, such as those in the Edna and Sisquoc regions in California, regions in Venezuela, and regions in Alberta, Canada, especially along the Athabasca and Peace Rivers. In the Athabasca River area alone anywhere from 200 to 1,500 billion barrels of oil may be present. However, only a small percentage of the oil is economically recoverable by the now operable Great Canadian Oil Sands process, wherein the tar sands are surface mined and the tar separated from the tar sands so mined. It is clear that, if the energy values are to be recovered from the vast majority of the tar sand deposits, they must be recovered in situ. The process of this invention provides a new and particularly effective means of obtaining energy values from tar sands, particularly the tar sands in the Peace River area.

It has been proposed to mine the tar sand and to recover oil from the mined sands by various operations requiring mechanical preparation followed by washing and heating. Such a process is described in U.S. Pat. No. 3,401,110 to P. H. Floyd et al. The cost of these operations on a commercial scale is excessive both in terms of capital investment and operating expenses, especially for deep deposits. And, as pointed out before, if the majority of the energy values are to be recovered from the tar sands, the values will have to be recovered using in situ methods.

Many attempts have been made in the past to apply secondary and tertiary oil recovery methods to recover tar from tar sand formations. Although these recovery methods are of interest, the technology is not always economically applicable to the treatment of tar sands. Various attempts have been made using soaks, drives, in situ combustion, and combinations thereof, but to date there has yet to be commercial production. Examples of some of the in situ methods used in attempting to recover hydrocarbons from tar sand and viscous oil-bearing formations include the following: U.S. Pat. No. 2,825,408 to Watson; U.S. Pat. No. 3,040,809 to Helser; U.S. Pat. No. 2,881,838 to Morris; U.S. Pat. No. 3,221,813 to Closmann; U.S. Pat. No. 3,396,791 to Van Meurs et al; U.S. Pat. No. 3,091,292 to Kerr; Canadian Pat. No. 679,222 to Muskat; and Venezuelan patents 631/72 and 632/72.

Another method is discussed in U.S. Pat. No. 3,439,742 to Durie which is useful in a formation wherein the permeability of the tar sand varies from being relatively water impermeable in the upper zone of the tar sand formation but relatively water permeable in the lower regions of the formation. In that process, a passageway is established between injection and production wells in the lower regions of the formation by injecting a fluid such as water or steam into the formation through the injection well to the production well, then a fluid, e.g., steam, is passed through the passageway from the injection well to the production well, thus entraining bituminous fluids with which the hot flowing fluid comes in contact. The mixture of bituminous fluids and hot fluids is then produced from the production well and the bituminous fluids are recovered therefrom.

In still another patent (U.S. Pat. No. 3,554,285 to Meldau) a process is described which is also useful in a formation comprising less water permeable oil-bearing sand overlying a more water permeable oil bearing sand zone. This process is very similar to the Durie process, above, except that after communication is established between the injection and production wells in the more permeable zone, the formation is heated to more than 550°F by injecting steam or an oxygen containing gas to establsih a combustion front, then heating is terminated to allow oil of decreased viscosity to flow into the permeable zone. This oil is then displaced towards the production well by again injecting the oxygen containing gas or steam, then the oil is pumped up from the well.

It has now been found that in a bituminous fluid-bearing formation characterized by having a relatively water-impermeable zone lying above and adjacent a water-permeable zone, if steam is injected into the permeable zone and maintained there at a high temperature and pressure, to decrease the viscosity of the bituminous fluid, in both zones, the bituminous fluid can later be produced by reducing the pressure in the permeable zone by increasing the flow of fluids through a production well and oil can then be recovered from these fluids. By this method oil recovery can be as much as 75 percent of the oil in place in the formation so treated.

SUMMARY OF THE INVENTION

This invention is a process for recovering bituminous fluid from a bituminous sand formation which contains at least one water-permeable zone and at least one adjacent, preferably overlying, water-impermeable zone and which has been penetrated by at least one injection well and at least one production well both of which communicate with a water-permeable zone. The process comprises

a. injecting a hot aqueous fluid, preferably steam, into the permeable zone to establish a hot, water-permeable channel between the injection and production wells, preferably so that the bituminous fluid in the channel has a mobility of at least 15 millidarcies/centipoise;

b. continuing the injection of said hot aqueous fluid at a rate sufficient to maintain the desired mobility level of the bituminous fluid in the channel and sufficient to increase the mobility of the bituminous fluid in the bulk of the formation to at least 15 millidarcies per centipoise;

c. reducing the pressure in said formation by increasing the production of fluids at the production well, and

d. recovering bituminous fluids from the fluids produced.

Preferably steam is initially injected into a production well at very high injection rates while at the same time water is produced from an injection well and the injection well backpressure is maintained as low as possible to promote a high rate of steam zone advance. Before the steam front from the production well reaches the injection well, injection of steam is initiated through the injection well to the steam-permeable zone to establish the hot channel between the two wells. Once the hot channel is established the production of fluid is substantially restricted, i.e., the production well is throttled back to minimize inefficient production of steam.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a vertical cross-section through a tar sand formation comprising an upper relatively water-impermeable zone and a lower water-permeable zone and illustrates an arrangement of wells for carrying out one embodiment of the process of this invention.

FIG. **2** is an overview of an idealized single **7**-spot producing pattern.

FIG. **3** is a graph presenting production-injection performance data for an experiment using the process of this invention on a laboratory scale.

DETAILED DESCRIPTION OF THE INVENTION

In general, although the process of this invention is described as being particularly applicable to recovery of bituminous fluids from tar sand formations, but it is understood that the process is applicable to other bituminous sand formations such as high viscosity oil-bearing sand formations which exhibit similar permeability properties, whether naturally occurring or man-made.

Tar sands are generally, but not always, characterized as being unconsolidated or friable structures which are either of a fluent nature, or they are held together by a bituminous material such that if this material is extracted at the surface, for instance, with toluene, the sands collapse. The bituminous fluid present in the tar sands frequently has an API gravity of between about 5°–15°, and is present to an extent in the tar sand formation of about 5–15 percent by weight. The bituminous fluid recovered by the process of this invention is the substantially hydrocarbon material which is associated with the inorganic material of the formation and can be referred to as bitumen, oil, tar, etc. For brevity this bituminous fluid will hereafter be referred to as tar.

The tar sand formations in which the process of this invention is particularly useful have a relatively water-impermeable zone lying adjacent, and preferably above, a relatively water permeable zone toward the bottom of the tar sand formation. Water in this context includes both liquid water and steam. For brevity these zones will be referred to simply as impermeable and permeable zones. Generally, there is no clean-cut division between the two zones which clearly identifies one from the other, but usually the top of the tar-bearing interval will exhibit a saturation which is typically 0.60–0.85 (i.e., 60–85 percent of the pore volume is filled with tar) while the lower extremities of the interval will range from about 0.0 to about 0.70. Most of the remaining pore volume is taken up by water, referred to as inplace water. The naturally occurring tar in the tar sand formation generally exhibits a very low mobility (permeability divided by viscosity). For instance, in the Upper Bullhead Formation of the Peace River Area in Alberta, Canada, the initial mobility of the tar in much of the reservoir is about 7×10^{-3} millidarcies per centipoise (md/cp). It will be apparent that the impermeable zone can be considered a relatively tar-rich zone while the permeable zone can be considered as a relatively tar-deficient zone. Both zones generally will be tar bearing. Thus when a fluid, such as steam, is injected into the formation the tendency of the steam is to preferentially enter the lower zone instead of the less permeable upper zone and steam communication will be preferentially established between wells through the permeable zone. Generally this type of formation is found in the Peace River area in Alberta, Canada, but such a formation may also be found in other areas where tar sands or viscous oil sands are located. The tar-bearing sand interval in such formations will lie below the surface of the earth and will generally be covered by an overburden of from about 100 feet to more than 1,000 feet. For the purposes of the process of this invention, it is preferred that the overburden be about 1,000 feet or more. The tar-bearing sand interval itself is generally at least 20 feet thick. Within such interval the permeable zone will be about 4 feet thick, with the impermeable zone making up the remainder of the interval. It is not unusual to find tar sand intervals 100 feet or more thick, wherein the impermeable zone is 50–90 feet thick.

The process of this invention can be more clearly described by reference to FIG. **1**, but it is to be understood that the following description is illustrative only and is not to be interpreted as limiting the scope of the invention.

Preferably the process of this invention is carried out in a tar sand formation **10** which has been penetrated by at least one injection borehole **11** and at least one production borehole **12** both of which communicate with the permeable zone **13**. (The production borehole is the one through which substantially all of the tar is ultimately produced, although as explained below, steam may be injected into this borehole.) Since, generally, the permeable zone **13** will lie below the relatively impermeable zone **14**, the boreholes pass through the over-burden **15** and the impermeable zone **14** to communicate with the underlying, steam-permeable zone **13**. The injection and production boreholes are established using methods known in the art so that communication can be properly established and maintained between the surface of the earth **16** and the bottom of the formation. Alternatively, one borehole may be drilled in which both production and injection facilities are positioned.

While the process of this invention preferably requires that at least one production and one injection well are in communication with the permeable zone, the number of wells used for production of large quantities of bituminous fluid using the process of this invention can be much greater, for example, anywhere from a total of 2 to 1,000 or more wells can be used. The wells are drilled using any of the known patterns, such as a **5**-spot, **7**-spot, **9**-spot, **13**-spot, etc., patterns, over an area of 1 to 10 or more acres per pattern. FIG. **2** depicts a **7**-spot pattern and is discussed below in Embodiment I.

The first step of the process involves injecting a heat carrying fluid, i.e., hot aqueous fluid, into the permeable zone to establish a hot, water-permeable channel between the injection and production wells, thus establishing hot fluid communication between the wells and increasing the temperature of the formation. The hot, permeable channel is formed, i.e., hot fluid communication is established, when the temperature of the produced fluids approaches that of the injected fluid and/or, in case of steam, when the bottom hole pressure of the production well approaches that of the injection well, i.e., there is a small difference in bottom hole pressures between the two wells. The hot aqueous fluid injected may be hot water, steam or mixtures thereof. Generally it is preferred to use steam but occasionally hot water is used to avoid plugging problems. The steam which is used in this process can be generally high or low quality steam and can be mixed with other fluids, preferably non-condensable gases such as air or flue gas. The steam is produced at the surface by using methods known in the art and can be superheated or wet, but it is preferred that the steam which enters the permeable zone be at least 50 percent quality and more preferably about 70–90 percent.

The steam is injected into the water-permeable zone of the formation at the highest practical rates, i.e., sufficient to establish a hot, water-permeable channel which exhibits a tar mobility of at least 15 md/cp in the shortest possible period of time. When the hot, water-permeable channel is established, a substantial portion of the pore volume of the permeable zone formerly occupied by in-place, relatively low temperature water and tar, is replaced by steam or hot water (condensed from steam or in-place water heated by the injected steam), and hot tar having a mobility of at least about 15 md/cp. Thus at this point the hot, water-permeable channel can be visualized as a passageway permeated by hot, aqueous fluids. The heat from the hot, aqueous fluids is transferred to the remaining tar occupying the permeable zone and adjacent impermeable zone to increase the tar's mobility within the formation. The injection rate will depend on the permeability thickness product of the permeable zone and the difference between the bottom hole injection pressure and the formation pressure. In some cases it is preferred to first fracture the formation to achieve the desired injection rates and speed the heating of the formation.

Generally steam is injected at rates varying from a few hundred, e.g., 200 barrels (Bbl) of water (as 1,150 Btu/lb steam) to several thousand, e.g. 5,000, bbl. per day. Under conditions existing in the upper Bullhead Formation of the Peace River Area, injection rates may typically be about 0.05 to 0.15 pore volume (PV) over a period of about 1 to 4 months (where 1 PV corresponds to about 1,320,000 Bbl for 7.0 acre per pattern spacing.

While steam is being injected at the highest practical rates through one well, the back pressure of the well from which fluids (predominently in-place water) are produced is kept as low as practical to promote a high rate of steam advance through the permeable zone. Preferably the steam is injected at a high rate originally through the production well **12** (indicated by arrows **18**) to maximize the length of time the zone **13** around the production well **12** is heated; and, at the same time, in-place water is produced through the injection well **11.** If more than one production well is used, injection into each producer may be staggered. When using a staggering technique, producers into which steam has already been injected are shut in to avoid inefficient production of steam and loss of heat, but otherwise fluids can be produced from them.

During the period that steam communication is being established between the production well **12** and injection well **11,** the steam injection pressure at the production well **12** is higher than the formation pressure so that a front **17** of steam moves through the permeable zone while at the same time heating the permeable zone **13,** which is being filled by the steam and hot water and forcing the in-place water out of the other well **11** (indicated by arrows **19**). Injection of steam through the producer can be continued until steam communication is established between the production and injection wells, but it is generally preferred that prior to the time that the steam front reaches the injection well, that is, after measurements indicate that the steam front has traversed from 50–90 percent (and preferably about 75 percent of the distance between the production well and the injection well, steam is then injected through the injection well to the permeable zone in order to establish the hot, water-permeable channel between the injection and production wells, thus minimizing the heat loss via produced fluids and the possibility of plugging due to a cooling tarbank. Generally this is accomplished by stopping water production from the injection well and switching steam injection from the production to the injection well no later than when the bottom hole temperature and pressure of the produced water approach those of saturated steam. The period necessary to establish hot fluid communication will be primarily dependent upon achievable injection rate and floodable reservoir volume per pattern and may range from a month or more to several years, e.g. **3,** but the most attractive times are less than about a year and preferably about 6 months.

Once hot fluid communication is established, i.e., the hot, water-permeable channel in which the tar has a mobility of at least about 15 md/cp is formed, steam may continue to be injected through the injection well at substantially the same rates or slightly less (e.g. 10–40 percent less) while at the same time the production well is throttled back, i.e., production of fluids is substantially restricted, so that the hot, water-permeable channel is established and expanded to the maximum possible size while minimizing inefficient production of steam from the production well. The high rate of injection is continued no longer than that time needed to obtain the desired mobility level of the tar in and near the channel, i.e., in a substantial portion of the permeable zone. The production well generally is throttled back shortly after hot fluid communication is established, not only to minimize loss of thermal energy through steam production, but also to reduce the period of time over which a high steam injection rate is to be maintained before desired steam temperature and pressure levels are attained throughout the permeable zone. It has been found that, since the heating of the overlying, water-impermeable zone occurs predominantly by conduction and not convection, the tar viscosity in the impermeable zone is efficiently reduced by raising the temperature (and thus the pressure) of the steam in the permeable zone to relatively high values.

After establishing the hot, water-permeable channel, the injection rate is decreased to a rate which is at least sufficient to maintain the mobility of the tar in said channel at the desired level; that is, enough steam is added to make up for the heat losses to the base rock, the overlying tar-rich zone, and the slight losses out the production well. This rate will generally be about one-tenth of the high rates used to establish a hot, water-permeable channel and is sufficient to increase the tar mobility in the bulk of the formation to at least about 15 md/cp. The bulk of the formation includes not only a substantial majority of the tar in the hot, water-permeable channel and permeable zone generally, but also a substantial portion of the adjacent impermeable zone, preferably at least a majority of the tar in the latter zone. Preferably, once the channel between wells is established, the desired temperature and pressure are also established and the injection rate of steam is decreased nearly immediately thereafter to desired maintenance rate. Throughout this temperature and pressure maintenance period, a high backpressure is maintained at the production wells to minimize the inefficient escape of steam and to assist in maintaining the high pressure level. The underlying permeable zone is typically maintained at high temperature and pressure for about 6 months to about 3 years, preferably about 2 years or less, to heat the overlying tar-rich section. The heating by conduction of the overlying tar-rich area lowers the viscosity of the tar thus increasing its mobility. Although it is not known exactly how the tar behaves after heating, it is thought that some tar moves into the lower hot aqueous fluid permeated zone and steam flows counter-current into the upper portion of the reservoir. In turn, this improved flow of steam is thought to accelerate the heating of the upper part to cause some drainage of tar (primarily by gravity forces) from the impermeable to the permeable zone. The length of maintenance of the relatively high pressure and temperature will depend in part upon the size of the overlying section, and generally increases as the vertical dimensions of the section increases. Thus for an impermeable zone of about 60 feet in thickness, the high-temperature/pressure-maintenance period will be about 1 to 2 years. An overlying tar-rich zone which is less than that thickness will, of course, require less time, while a thicker tar-rich zone will require a greater period of time.

Generally the temperature and pressure of the formation are increased to a level at which the tar of the impermeable zone becomes mobile, i.e., will flow relatively easily either by gravity or to an area of reduced pressure. The pressure level at which the formation is to be maintained is larger than reservoir pressure, preferably about 500 to 2,500 pounds per square inch (psi) and even more preferably about 1,200–1,500 psi, while the temperature is maintained at corresponding saturated steam temperatures at the injector and in the permeable zone and sufficiently high at the producers so that tar mobility in the bulk of the formation is at least 15 millidarcies/centipoise (md/cp), and preferably about 20 md/cp or more. The maximum temperature generally will be no more than the critical temperature of water (706°F) and preferably is about 500°F, while the minimum temperature is about 300°F.

It has been found that it is preferable to include, along with the steam preferably during the maintenance period, i.e., after hot fluid communication has been established, a noncondensable gas, such as air or flue gas under non-combustion conditions, as a means for accelerating oil production during the throttled production period. Because of its availability air is preferred. The noncondensable gas can be added in a ratio of about 50 to 150 cubic feet of gas per barrel of steam.

After the high temperature/pressure period has been maintained for a sufficient period of time, i.e., about 6 months to about 3 years and preferably about 2 years, a blowdown period is initiated wherein formation pressure is gradually reduced from the level at which it was being maintained (i.e., about 1,200–1,500 psi) to about 100–500 psi (preferably about 100–200 psi and most preferably about 100 psi) over a period of about 2 to 5 years. It is thought that the tar is forced out of the formation by a combination of the expansion of the high-pressure steam present in the reservoir and the gases generated by the vaporization of the hot water and hydrocarbons as the reservoir pressure is reduced. During the blowdown period the steam injection continues but still at a very low rate, that is, enough to keep the temperature of the steam-filled zone at least at the bottom hole producing temperature, to maintain communication between the injection and production wells, and to maintain a pressure difference to improve oil production. During this blowdown period steam is injected at substantially the same rates it is added during the pressure maintenance. The pressure is reduced during the blowdown period merely by allowing the fluids accumulated in the steam zone and mobilized in the formation to flow through the production well and thereafter, of course, recovering the oil or bituminous fluid from the fluids produced from the well.

Generally, the best results have been observed using the above sequence of steps, but certain improvements can be obtained by limiting the blowdown cycle to a shorter period of time and following it by a second high pressure period and then a final blowdown period. The purpose of the second pressurization is to force steam into those parts of the upper tar-rich zones which were not depleted during the first short blowdown. This particular method is useful where the overlying tar-rich zone is thicker than the usual 50–90 foot-size impermeable zone. Flowing the steam for the second time into this upper portion would result in more rapid heating than by conduction alone from the underlying steam channel, but such a multiple pressurization is generally not needed for a 60-foot reservoir. Instead of having a lengthy second pressurization period as described above, it is also possible to use a series of short-duration blowdown pulses, during the initial pressure maintenance phase, that is, reducing the pressure in the permeable zone over a short period of time, for example a week to two months, then immediately thereafter gradually returning the steam zone to the high pressure condition. It is thought that by developing a high pressure difference, the downward flow of the hot tar is accelerated during the blowdown pulses, and the upward steam flow into the depleted regions during the subsequent repressurization is improved. Again, this particular variation in the method is of more importance where the upper zone is thicker than about 50 to 90 feet.

This invention will be further explained in detail with reference to the following specific embodiments which are given by way of illustration only and not by way of limitation.

EMBODIMENT I

A physical model which simulated natural conditions in the Upper Bullhead Formation of the Peace River area tar sand accumulation was developed in the laboratory which was characterized by having a high permeability sand layer at the bottom of the simulated tar sand formation. The model represented a double-element of symmetry for a single **7**-spot well pattern corresponding to 7.0 acres per pattern, i.e., one injection well and two production wells about 340 feet apart. The properties of the model were such that the thickness of the upper relatively bitumen-rich steam-impermeable layer corresponded to about 60 feet while the lower steam-permeable layer corresponded to about 30 feet. The permeability of the upper layer was 345 millidarcies (md) which was less permeable than the lower layer's permeability of 1,665 md, while the porosity of each of the layers was 0.27 (ratio of volume of the interstices to volume of the overall mass). The tar saturation of the available pore space in the upper layer was about 0.80 while the tar saturation in the lower zone was 0.65. The model was further set up so that all wells has fractures with radii equal to 17.5 percent of the interwell distance (60 feet for the 7 acre, **7**-spot pattern).

FIG. **2** shows the double element of symmetry and one **7**-spot well layout represented by the physical model. Numbers **12** and **12'** represent wells through which the bitumen is ultimately produced, thus are referred to as production wells, while **11** represents the well into which steam is injected during bituminous fluid production. The crosshatched area in FIG. **2** is the area studied in the physical model.

FIG. **3** shows the results from employing the process of this invention in the physical model. Results show that an oil recovery of 0.49 PV is obtained over about a 7 year period with a total steam injection of 2.22 PV and an oil/steam ratio in Bbl/Bbl of 0.22. In this experiment steam was injected into production well **12** for a period of about 1 month, followed thereafter by steam injection into production **12'** for a month, then the cycle was repeated. (See the upper left hand corner of FIG. **3**). During this time a low back pressure was maintained at injection well **11** to promote a high rate of steam advance. Thereafter, steam was injected into well **11** while the back pressure of production wells **12** and **12'** was kept at a low value to promote a high rate of steam advance. Then wells **12** and **12'** were throttled back so that the pressure and temperature of the steam zone would be maintained at a high level. While the steam is being injected into the injection well it is difficult to maintain the exact same pressure in the steam zone as indicated by the fluctuation in the pressure curve labeled P_{max} in FIG. **3**. However, the pressure is maintained at about 1,200–1,700 psi before the final blowdown period begins. It should be noted that although the production wells are throttled for a period of about 2 years, there is a small amount of fluid produced during this period due to the need to insure steam communication between wells, and some bitumen is included therein, but it is clear from the results that the majority of the production occurs during the blowdown phase. The mobility of the tar towards the early part of production was about 20 md/cp, while towards the end of producing the mobility increased to about 100 md/cp, probably due, i.e., to the extensive heating which the later-produced tar underwent in the formation.

In FIG. **3** "BDW percent Quality" indicates the number of barrels per day water injected as steam and the per cent quality of the steam injected. Thus 3,965 BDW/90percent indicates 90percent quality steam was injected at a rate of 3,965 barrels water per day. Equivalent steam is the amount of water (at standard conditions) injected assuming all of it was converted to 1,150 btu/lb steam.

We claim as our invention:

1. A process for recovering bituminous fluid from a bituminous sand formation which contains at least one water-permeable zone and at least one adjacent, water-impermeable zone and which has been penetrated by at least one injection well and at least one production well, both of which communicate with said water-permeable zone, said process comprising:

a. injecting a hot aqueous fluid into said formation through at least one well while producing fluids at at least one other well to establish a hot, water-permeable channel extending between the injection and production wells;

b. continuing the injection of said hot aqueous fluid at a rate at least sufficient to maintain said bituminous fluid mobility within said channel and to increase the mobility of the bituminous fluid in the bulk of the bituminous sand formation surrounding said path to at least 15 millidarcies per centipoise;

c. reducing the pressure in said formation by increasing the production of fluids at the production well; and

d. recovering bituminous fluid from the fluids produced.

2. The process of claim **1** wherein the highest practical injection rates are maintained until said hot, water-permeable channel is established.

3. The process of claim **2** wherein the rate of production of fluids at the production well is substantially restricted after said hot channel has been established between said injection and production wells.

4. The process of claim **2** wherein before said hot channel is established the back pressure of the well through which fluids are being produced is maintained at a low value to promote a high rate of growth of said channel in the permeable zone.

5. The process of claim **1** wherein said water-impermeable zone lies above said water-permeable zone.

6. The process of claim **1** wherein said hot aqueous fluid is steam.

7. The process of claim **6** wherein the highest practical injection rates are maintained until said channel is established.

8. The process of claim **7** wherein before said channel is established, the back pressure of the well through which fluids are being produced is maintained at a low value to promote a high rate of steam advance in the permeable zone.

9. The process of claim **7** wherein steam is first injected through the production well to establish said hot channel.

10. The process of claim **9** wherein a steam front moves through the permeable zone to force the in-place water from the formation out the injection well, and, before said steam front reaches the injection well, water production from the injection well is stopped and steam is then injected through the injection well to said permeable zone.

11. The process of claim **10** wherein steam is injected through said injection well when said steam front has advanced about 50 to 90 per cent of the distance between said production well and said injection well.

12. The process of claim **8** wherein the rate of production of fluids from the well from which fluids are being produced is substantially restricted shortly after said channel is established.

13. The process of claim **12** wherein the rate of steam injection is maintained at substantially the same rate as step (a) until mobility value of at least 15 millidarcies/-centipoise for said bituminous fluid in said permeable zone is attained, then the rate of injection is decreased to a rate sufficient to maintain said mobility value for the tar in said permeable zone and increase the mobility of the tar in the bulk of the formation to 15 millidarcies/centipoise.

14. The process of claim **13** wherein the decreased rate of steam injection is maintained for about six months to about three years.

15. The process of claim **14** wherein the pressure of the heated formation is maintained at a higher value than the initial reservoir pressure and the temperature is maintained at the corresponding saturated steam temperature.

16. The process of claim **15** wherein the pressure of said permeable zone is gradually reduced to about 100 to 200 pounds per square inch over about 2 to 5 years.

17. The process of claim **1** wherein a non-condensable gas is injected into the permeable zone along with the hot aqueous fluid.

18. The process of claim **17** wherein the non-condensable gas is air.

19. The process of claim **6,** wherein a non-condensable gas is injected into the permeable zone along with said steam.

20. The process of claim **19,** wherein the non-condensable gas is air.

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