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(54) **IN-SITU EXTRACTION OF
HYDROCARBONS FROM OIL SANDS**

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(75) **Inventor: Udo von Wimmersperg**, Bellport,
NY (US)

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(57) **ABSTRACT**

Correspondence Address:
LOUIS VENTRE, JR
2483 OAKTON HILLS DRIVE
OAKTON, VA 22124-1530

A device and method of using the device enable the in-situ extraction of hydrocarbons from oil sands and other hydrocarbon resources. The preferred embodiment of the device includes at least two electrodes of tubular form wherein said electrodes are porous and capable of being inserted into the ground; a source of electrical current to apply to the electrodes; and a means for extracting the hydrocarbons from the tubular electrodes. In the preferred embodiment of the method of the invention, the electrodes are inserted into the oil deposit and connected to an electrical potential difference sufficient to drive an electric current between in-ground electrodes. Current is then flowed between the electrodes. The pressure gradient, resulting from heating the oil-bearing fluid, drives product into the tubular electrodes where it is removed.

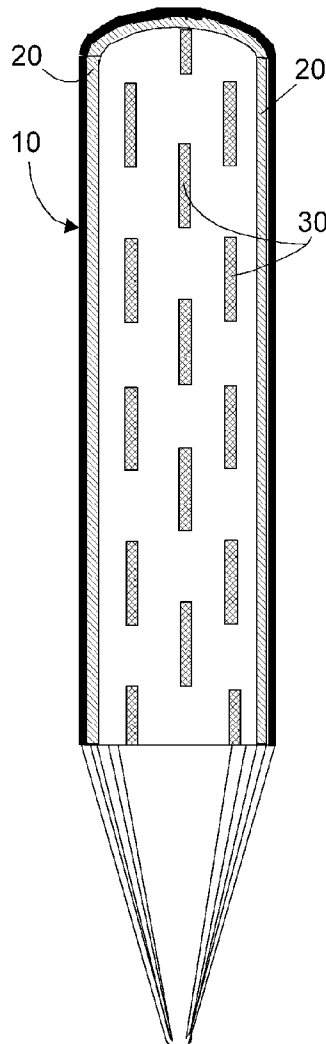
(73) **Assignee: HCE, LLC**, Oakton, VA (US)

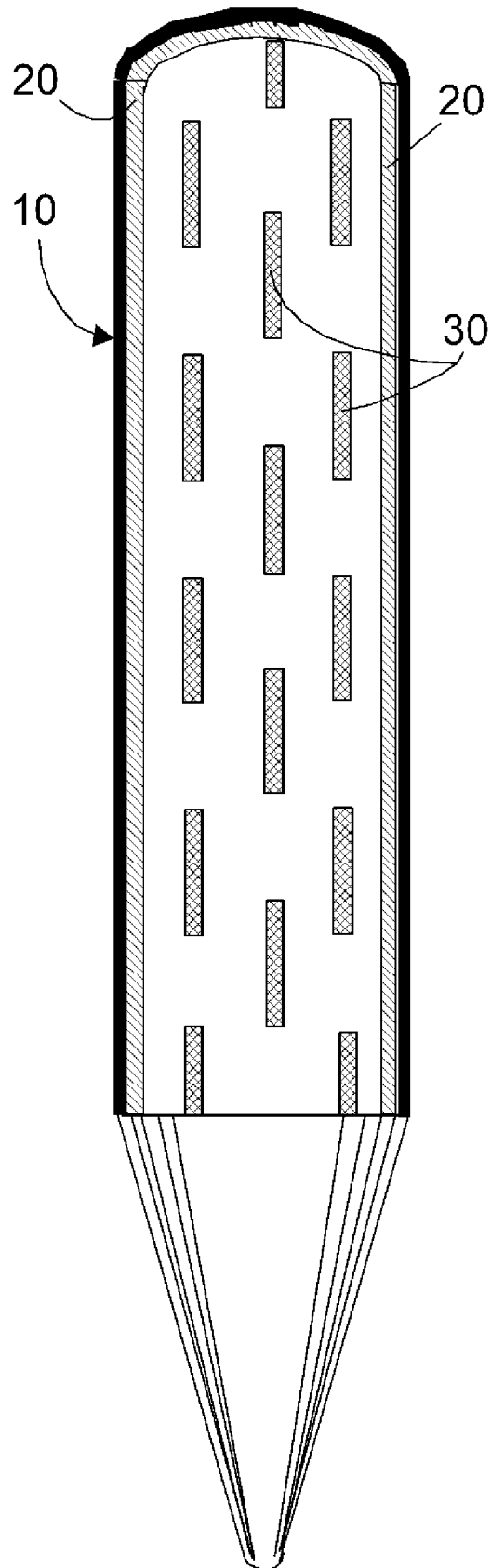
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IN-SITU EXTRACTION OF HYDROCARBONS FROM OIL SANDS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Pursuant to 35 U.S.C. section 119(e), the present invention claims the benefit of the filing date of U.S. provisional application 60/767120 filed 4 Mar. 2006, the text of which is included by reference herein.

FIELD OF INVENTION

[0002] In the field of hydrocarbon extraction from in-ground oil sands or similar deposits, a device and method of using the device for the extraction of the hydrocarbons.

BACKGROUND OF THE INVENTION

[0003] The invention is termed "IXOS," an acronym of sorts derived from In-Situ Extraction of Hydrocarbons from Oil Sands." IXOS employs an electric current between porous, tubular in-ground electrodes to flow hydrocarbons in a deposit into the electrode. Electric resistance heating of the oil-bearing fluid in the ground between the electrodes creates a pressure gradient, which drives hydrocarbon product into the electrodes. As long as the electrode is porous, then product can be collected from within the electrode. This method has not heretofore been used in any field relating to the extraction of oil from the ground.

[0004] The method of the invention is estimated to require an energy input equaling about 2% of the heating value of oil recovered. This calculation is based on an average of oil content of 14% by weight oil in the oil sand and 2% by weight of water and assuming all the electrical energy can be directed into the conductive water layer. This is a significant improvement over the state of the art, and unlike any other method, allows a wide margin for other heat losses in the process without impacting the energy balance for oil production from the deposit.

[0005] Energy savings from the invention are maximized taking advantage of the fact that the conductivity of oil sands is due to the interstitial liquid, the dielectric sand grains themselves having low conductivity. An electric current (flowing between electrodes or induced) heats up this interstitial liquid instantaneously, compared to steam flow and thermal conduction previously used in the industry.

[0006] Oil sands, also referred to as tar sands and bituminous sands, are a combination of clay, sand, water, and bitumen. Bitumen is the soluble organic matter and is an asphalt-like substance, which can be refined into oil. Oil sand deposits are typically mined using strip-mining techniques, which extract the oil sands from the ground for processing to recover the bitumen.

[0007] Tar sands deposits are found all over the world, with the largest deposits found in Venezuela and Alberta, Canada. These two deposits have been estimated to contain about 600 cubic kilometers of oil sands, equivalent to about twice the world's reserves of oil or about 3.5 trillion barrels of oil. The United States contains scattered deposits of oil sands, mainly in Utah, Kentucky, Kansas, Missouri, Oklahoma, California, and New Mexico. The ability to economically recover these deposits would help to diversify oil sources and contribute to U.S. national and energy security.

[0008] The invention may also be used for the extraction of oil in similar deposits, for example, in oil shale. Oil shale

is a general term for shales rich enough in bituminous material to yield petroleum upon heating in low oxygen environments. The United States Office of Naval Petroleum and Oil Shale Reserves estimates a world supply of oil shale of about 1,700 billion barrels of which about 1,200 billion barrels is in the United States, Estonia, Russia, Brazil, and China.

DESCRIPTION OF PRIOR ART

[0009] In a common oil extraction process, hot water is added to mined oil sand to liberate the bitumen from the sand and clay. The resulting slurry is piped to an extraction plant where the slurry is agitated to allow small air bubbles to attach to bitumen droplets. Froth is created, which is skimmed off the top and treated to remove residual water and fine solids. Bitumen is then upgraded in a coker, which cracks the bitumen into lighter oils and gases. Further processes create a blended synthetic crude oil.

[0010] An oil sands processing plant will typically consume over a million gallons of water every hour. The more efficient of such plants consume about 92 gallons of water per 42-gallon barrel of syncrude produced. Such a plant could produce about 75 million barrels of syncrude per year. Of the water used typically, about 250,000 gallons per hour is too contaminated with dissolved hydrocarbons and minerals for recycling. This quantity is sent to a tailings pond. While a tailings pond typically prevents contaminated water from mixing with potable water supplies, this much ponded water requires active management to permit settling of fines, to prevent it from combining with clean surface water and to preclude accidental release. The wet sand and clay residues can also be caustic and require extensive and expensive neutralization. This caustic aqueous residual often has a high Chemical Oxygen Demand, which robs the water of oxygen. This, in turn, makes the ponds containing such residual, hypoxic and adverse to plant and animal life.

[0011] Improvements in the basic hot water process have been disclosed, for example in U.S. Pat. No. 6,576,145 to Conaway on Jun. 10, 2003. The '145 patent is a continuous process where the mined oil sand is crushed to the particle size of sand or smaller, then mixed with water to form a slurry, then heated and blended with an oxidant in aqueous solution, such as hydrogen peroxide. This process releases the free interstitial hydrocarbons and those hydrocarbons bound electrostatically to the surfaces of clay-like particles in the ore. This process attempts to reduce water consumption through recycle and seeks to lower costs. However, while improved, this process has many of the same shortfalls of the basic hot water process.

[0012] It has been estimated that the equivalent of one barrel of oil is needed to process three barrels of synthetic crude obtained from oil sands using the hot water process. Aside from the cost, this much energy consumption translates to significant emissions of carbon dioxide, a greenhouse gas.

[0013] Five major disadvantages of producing oil from strip mined oil sands are (1) the need to consume large quantities of clean water resources, (2) the need to consume energy to heat the water, (3) the subsequent pollution of the water by chemicals extracted from the deposits, (4) a high cost of production; and (5) large up front capital investment is needed partly because very large separation plants are needed for processing the bitumen.

[0014] Since up to 80% of the oil sands deposits may be too deep underground for strip mining, other mining techniques have been employed. For example, in-situ mining techniques are practiced to extract the bitumen without removing oil sands from their in-ground location.

[0015] One such in-situ method requires a large source of steam, an injection borehole and an extraction borehole. This method is sometimes called "Steam-Assisted Gravity Drainage." The steam is injected into the oil sands deposit where the combination of high temperature and steam creates a largely gaseous product that will flow and can be channeled to the extraction borehole. The product flow is liquefied before reaching the surface and pumped out of the extraction borehole. This in-situ technique suffers from the disadvantages noted in the preceding paragraph for the aboveground hot water process. In addition there is a potential for pollution below the surface.

[0016] The current invention improves on Steam-Assisted Gravity Drainage by employing controlled deposition of heat. In response to a current pulse between electrodes, resistive ionic conduction through paths of fluid interstitial to the dielectric grains in the body of oil sand produces an overpressure pulse. This drives the oil-bearing fluid towards the low-pressure outlets at the electrodes. Instantaneous heating with the IXOS device is dominant in the process. This compares to a slower rate of thermal conductive heating using the steam process. Therefore, the preferred embodiment of the present invention, which employs a high current pulse of short duration, offers significant benefits over steam extraction by minimizing wasted energy otherwise used for warming the ore (sand) in the deposit.

[0017] Another such in-situ method uses dissolution chemicals to dissolve the bitumen. The dissolved bitumen then flows to an extraction point, where it is removed for processing to extract the oil and recycle the dissolution chemicals.

[0018] All of the existing methods of extracting oil from oil sands have a large environmental cost. When strip mining is employed, two tons of mined sand are required to produce one barrel of synthetic crude. This leaves a significant tailings pile. The water ponds required to dispose of the water used in the process are contaminated and consume large tracts of land. Such underground processes also have potential to contaminate water aquifers.

[0019] The preferred embodiments of the device and method of the invention address many of the deficiencies found in the state of the art of oil extraction from oil sands. In particular, the present invention provides an in-situ process similar to an oil well, while eliminating extraction of oil sands and recovery of dissolution chemicals.

[0020] The preferred embodiment of the invention simplifies the process of oil extraction from oil sands by eliminating much of the surface infrastructure required to extract the oil sands and bitumen from the ground.

[0021] The preferred embodiment of the invention eliminates the need to consume large quantities of clean water resources. No water is used in the IXOS extraction process, except for the water already present in the deposit. Water is used only to provide minimal equipment cooling and to satisfy minor process needs.

[0022] The preferred embodiment of the invention avoids most of the cost, pollution and energy associated with the use of water and dissolution chemicals in the current methods. The preferred embodiment of the invention will help

with minimization of cost, both in capital equipment and operation. The cost of electrical power is offset by low energy requirements. The costs for energy for extracting the bitumen are estimated to be about 2 percent of heating value of the oil recovered.

[0023] Pollution and energy are reduced as a necessary consequence of not using water and not needing to consume energy for heating water. Of major importance is the environmentally non-intrusive nature of in-situ production.

[0024] In terms of heating oil shale deposits for removing the oil, U.S. Pat. No. 6,929,067 to Vinegar, et al. on Aug. 16, 2005, which is incorporated by reference as if fully set forth herein, provides a thorough reference and description of heat sources with conductive material for in situ thermal processing of an oil shale formation. Essentially, the state of the art for electricity driven heating methods described involve electrically-powered, resistive heating elements placed in a well bore drilled into the formation. The heating elements are energized, much like that on an electric stovetop, and the heat generated by the elements is either carried to the formation by conduction or by radiation.

[0025] The preferred embodiment of the invention is different from all of the prior art described in the '067 patent in that this embodiment uses the in situ formation itself as the medium for carrying a current and, thus, heating itself from the flow of current.

[0026] It is therefore apparent that a need exists for a non-water consuming process for extracting oil from oil sands. It is further apparent that such a process that is also lower-cost, lower polluting, and lower energy process would significantly enhance the state of the art for producing oil from oil sands.

BRIEF SUMMARY OF THE INVENTION

[0027] A device and method of using the device provide for in-situ extraction of hydrocarbons from oil sands and other hydrocarbon resources. The preferred embodiment of the device includes at least two electrodes of tubular form wherein said electrodes are porous and capable of being inserted into the ground; a source of electrical current to apply to the electrodes; and a means for extracting the hydrocarbons from the tubular electrodes. In the preferred embodiment of the method of the invention, the electrodes are inserted into the oil deposit and connected to an electrical potential difference sufficient to drive an electric current between in-ground electrodes. Current is then flowed between the electrodes. The pressure gradient, resulting from heating the oil-bearing fluid, drives product into the tubular electrodes where it is removed.

BRIEF DESCRIPTION OF THE DRAWING

[0028] The drawing is a sectional view of the tubular porous electrodes for the in-situ extraction of oil from oil sands.

DETAILED DESCRIPTION OF THE INVENTION

[0029] The device and method of using the device for the in-situ extraction of hydrocarbons from oil sand (herein referred to as "IXOS") are based on the using the ionic resistivity of the hydrocarbon formation, also referred to as a deposit, by passing a current between electrodes in the formation.

[0030] The preferred embodiment of the IXOS device first includes a plurality of tubular porous electrodes similar to the one shown in the drawing. The tubular shape is typical of a well pipe or casing used in the oil industry. The porosity of the electrodes may be obtained by employing perforations, for example in the form of a pattern of short vertical slots (30) in the wall of the electrode tubes.

[0031] The electrodes are also similar to well-known technology of well points used for ground water extraction in that they are suitable for being inserted into the ground. While well points are porous casings used to extract water from an in ground well, the electrodes are used to extract hydrocarbons, such as soil containing a deposit of oil. Two significant differences from well point technology are the ability of the electrodes to carry electrical current for heating the ground deposit, and a consequent ability to motivate flow of the hydrocarbons from the ground resource into the hollow body of an electrode incident to extraction. In the preferred embodiment, the flow of electrical current between two or more electrodes is what motivates the flow.

[0032] The diameter and length of the electrodes can vary as required by the resource deposit. Typically, the electrodes would be steel tubes or casings (10) of about six-inches in diameter with a thickness of copper (20) on the inner wall to serve as a current carrier. However, electrode diameters of 10 feet, 20 feet or more are also within the scope of the invention. The length of the electrode is limited only by practicality constraints of handling and insertion into the deposit. Short lengths of electrodes may be joined in the same manner as well piping to make the electrode length any desired length suitable to the deposit and the source of power. Similar to a well point, an electrode may be fitted to the end of a pipe or casing. However, unlike a well point, the electrode must be insulated from the pipe or casing so that it is capable of delivering current to the specific resource location in the ground. At least two electrodes are needed in the preferred embodiment for the operation of the invention, and there is no limit on how many may be used.

[0033] The preferred embodiment of the IXOS device next includes a means for extracting the hydrocarbons from the tubular electrodes. In this embodiment, this means for extracting is a valve that is opened to allow the pressurized hydrocarbons and steam to flow out of the electrodes. In alternative embodiments, this means for extracting is a pump, which, for example, may either be placed within the electrode or on the surface.

[0034] The preferred embodiment of the IXOS device lastly includes a source of electrical current to apply to the electrodes. This typically means applying an electrical potential difference across two or more electrodes so that current will flow between them. Alternating or direct current may be employed.

[0035] In using the preferred embodiment of the IXOS device, the electrodes are inserted into the hydrocarbon containing deposit a distance from each other. Such distance is dependent upon the electrical resistivity of the ground and the electrical potential difference available to apply between electrodes. The determining factor is that the current passing through the deposit and between the electrodes must be sufficient to heat the deposit. Typically with tens of kilovolts available to apply to the electrodes, the electrodes would be spaced tens of meters apart.

[0036] In the preferred embodiment, the casings are vertical in orientation, but they may be in any orientation as

long as they provide access to the surface so that the hydrocarbons can be removed from the tubular electrodes.

[0037] In the preferred embodiment of the method of the invention, a potential difference is applied between electrodes so that a current runs between them sufficient to heat the ground, that is, the deposit between the electrodes. For example, a 60 Hz potential difference in the range of several kilovolts causes an ionic current distribution in the conductive interstitial medium between the grains in the oil sand. Ionic resistance will generate local heating within the interstitial medium, causing the sequential melting of ice, the dislodging of oil particles, and pressure buildup through steam formation. Thus, the preferred embodiment of the invention avoids unnecessary heating of the bulk of the ore (sand) both by placing the heat exactly where it is needed (in the interstitial liquid), and by forestalling thermal conductivity losses. These embodiments take advantage of the benefit obtainable by employing a large current pulse of short duration to minimize conductive heat losses and to build high pressure for expelling product.

[0038] While the invention includes the application of a small current over a long time, embodiments of this type are less efficient in product delivery and more wasteful of energy. Such embodiments will work, but they promote less useful conductive heating of the bulk sands, and deliver a comparatively weak pressure rise from the vaporized liquids, which drive product into the electrode wells.

[0039] The preferred embodiment employs a current of about 1,000 amps delivered over a duration from about 20 seconds to 2 minutes. The current density can be reduced by increasing the diameter of the electrode. In one embodiment, pulsed current is generated on site using a motor and flywheel configured such that after the flywheel reaches a rotation corresponding to the energy desired, that rotational energy is discharged by turning a generator, which creates the desired pulse of electrical current.

[0040] A porous electrode allows ingress of steam-driven oil while keeping out sand grains. In this way each electrode essentially becomes a production well. The means for extracting the hydrocarbons is employed to produce oil and other hydrocarbons from the deposit.

[0041] The process works most efficiently when the current passing between electrodes is of such magnitude and duration that it does not directly heat the dielectric quartz sand grains. Thus, for the preferred embodiment, such current is pulsed and has a duration that minimizes thermal conduction into the solid centers of the sand grains. For this to occur, the resistive heating is applied rapidly enough to suppress to some extent the thermal conduction into the solid centers of the sand grains. This saves on energy consumed by the extraction process and contributes to an efficient process.

[0042] Important aspects of the process of using the invention are the modes of flexibility for adapting to different ground conditions present in a deposit.

[0043] A primary mode of flexibility relates to the electrodes, which can easily be rearranged and adapted to different conditions without the construction of new equipment. Hardness of the sand deposit and viscosity may vary radically with seasonal temperature changes, and the composition and physical nature of oil sands may differ substantially from one geographical location to another. In particular, this process is suitable for locations where the deposit, for example oil sand, is under large overburdens. In

such cases, the embodiment would include electrically insulating sleeves over the electrodes where the electrodes are in contact with the overburden. Also, an alternative embodiment employed in such cases, comprises the electrode at the end of a casing penetrating the overburden wherein the electrode is electrically insulated from the casing. The presence of an overburden is expected to be of benefit when it acts as a seal for trapping vapor pressure.

[0044] Further modes of flexibility involve adjustable variables for optimizing the extraction of hydrocarbon from the deposit. These include voltage and frequency, geometry of electrode matrix, and time structure of electrical current.

[0045] In an alternative embodiment of the method of using the device, there is an additional step of injecting an electrolyte into the deposit. For example, in an oil sand deposit, salt water is injected through the electrode slots to raise conductivity of the deposit and to clear sand blockages of the electrode slots.

[0046] In an alternative embodiment of the method of using the IXOS device, there is an additional step of pressurizing one or more of the electrodes with nitrogen gas. This step helps to drive the oil product to unpressurized adjacent electrodes.

[0047] The description above and the examples noted are not intended to be the only embodiments of this invention and should not be construed as limiting the scope of the invention. These examples merely provide illustrations of some of the embodiments of this invention. Others will be obvious to those skilled in the art. Thus, the scope of the invention is determined by the appended claims and their legal equivalents rather than by the examples given.

What is claimed is:

1. A device for the in-situ extraction of hydrocarbons comprising,
 - a plurality of electrodes in tubular form wherein said electrodes are porous and capable of being inserted into the ground;
 - a source of electrical current to apply to the electrodes;
 - and,
 - a means for extracting the hydrocarbons from the tubular electrodes.

2. The device of claim 1 wherein the electrodes are steel tubes of six-inch diameter with a thickness of copper on the inner wall.

3. The device of claim 1 further comprising electrically insulating sleeves installed over the electrodes where the electrodes are in contact with overburden.

4. The device of claim 1 further comprising an electrode at the end of a casing wherein the electrode is electrically insulated from the casing.

5. The device of claim 1 wherein the source of electrical current is capable of providing a pulsed current.

6. The device of claim 5 wherein the pulsed current is at least about 1,000 amps current over a period of about 20 seconds to 2 minutes.

7. The device of claim 5 wherein said source of electrical current is a motor and flywheel configured such that after the flywheel reaches a rotation corresponding to the energy desired, that rotational energy is discharged by turning a generator, which creates the desired pulse of electrical current.

8. The device of claim 1 wherein the means for extracting is a valved pipeline.

9. The device of claim 1 wherein the means for extracting is a pump.

10. A method of using the device of claim 1 comprising the steps of, inserting the electrodes into a hydrocarbons deposit in the ground;

- running a current between the electrodes of sufficient magnitude to heat the ground between the electrodes;
- and,

- extracting the hydrocarbons from the electrodes.

11. The method of using of claim 8 further comprising the step of injecting an electrolyte into the deposit through the electrodes.

12. The method of using of claim 8 further comprising the step of pressurizing one or more of the electrodes with nitrogen gas.

13. The method of using of claim 8 wherein the current is pulsed and has a duration that minimizes thermal conduction into the solid centers of the sand grains.

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