

TITLE OF THE INVENTION

Bitumen Recovery Process

BACKGROUND OF THE INVENTION

There are several known techniques for enhanced oil recovery from underground formations. Some of those techniques use heating of the formation in order to increase the flow of bitumen and allow easier recovery. One of these techniques is known as steam assisted gravity drainage (SAGD).

Other enhanced oil recovery technologies include introducing a heating element to the underground formation. The heating element can be any type known in the art, including the following: 1) a continuous tube having an electric heating element or 2) a continuous tube permitting circulation of a heated fluid such as steam, gas, superheated liquid, molten salts, or other heated fluids known in the art. These heating elements are typically utilized to preheat the underground formation prior to injection of the steam into the formation.

Further enhanced oil recovery technologies utilize a solvent assisted technique. The solvent assisted technique includes the following steps: 1) the solvent is injected into the formation; 2) the solvent is mixed with the bitumen; 3) the solvent/bitumen mixture is recovered from the bitumen formation; and 4) the solvent is separated from the bitumen, recycled and then used in the formation again.

Recent developments in enhanced oil recovery technologies include US 2011/0303423. US 2011/0303423 teaches recovering in situ viscous oil from an underground reservoir. Electricity is conducted through the underground reservoir by at least two electrodes in an amount that would, in the absence of solvent injection, cause water in the reservoir to vaporize adjacent to the electrodes. Solvent is injected into the reservoir to mitigate water vaporization adjacent to the electrodes by vaporizing solvent in this region. Oil and solvent are produced through one or more production wells. However, the method disclosed in US 2011/0303423 does not contemplate an energy efficient process that reduces both solvent usage and water treatment procedures.

The known enhanced oil recovery technologies are heavily investigated, but still require improvements at every stage. The required improvements include 1) simplifying oil recovery the process; 2) reducing the need for materials such as steam and solvents thereby reducing energy consumption for steam generation; 3) reducing water treatment procedures; and 4) improving the process solvent recovery from the bitumen mixture.

SUMMARY OF THE INVENTION

Disclosed herein is a process for recovering hydrocarbons such as bitumen from an underground formation which is designed to increase energy efficiency by reducing 1) surface water treatment and 2) solvent usage.

In one aspect, the bitumen recovery process comprises the following steps:

- a) Drilling a single well into a bitumen deposit;
- b) Equipping said well with a heating element, a solvent injecting member, and a bitumen recovering member;
- c) Injecting said well with a solvent having a low flash point through said solvent injecting member;
- d) Heating said solvent with the said heating element to a vapor state while keeping the temperature and pressure in the well at a predetermined condition;
- e) Mixing said solvent vapor with bitumen in the deposit thus reducing said bitumen viscosity;
- f) Draining said bitumen to the bottom of the well proximate the heating element;
- g) Heating the bitumen to keep its viscosity low, enabling recovery of the bitumen by bitumen recovering member;
- h) Evaporating at least part of solvent entrapped in the bitumen at the bottom of the well by the heating element;
- i) Recovering said bitumen and traces of water from the well by said bitumen recovering member;
- j) Condensing said solvent inside the well for further reaction with the bitumen in the deposit;
- k) Repeating steps h through j, wherein the majority of said solvent does not leave the well during the bitumen recovery process.

In one embodiment, the heating element utilizes electricity, steam, or a hot fluid circulating through the well. In a further embodiment, the heating element utilizes electricity, steam, or a hot fluid circulating through the well in a tube. In yet another embodiment, the electricity, steam, or hot fluid is reheated at the surface or in the bore of the well.

In one embodiment, the solvent used in the process comprises propane, butane (normal, iso & mixed), pentane (normal, iso & mixed), or hexane (normal, iso & mixed). In a further embodiment, the solvent is a mixed solvent with a composition from C3 to C8. In yet another embodiment, the solvent is a mixed solvent with a composition from C5 to C7. Even further, the solvent composition is a heavier C7 in the initial recovery process and is progressively replaced

with lighter hydrocarbons as the process continues. In one embodiment, steam is injected into the well along with the solvent.

In one embodiment, the produced fluids recovered from the well are primarily bitumen or heavy oil with a small amount of miscible contained solvent and some connate water.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of single well heating.

Figure 2 is a cross-sectional view of the end of pre-heating the single well.

Figure 3 is an alternative view of the end of pre-heating the single well.

Figure 4 is a cross-sectional view of the single well near abandonment.

Figure 5 is a production profile of single well heating.

Figure 6 is a graph showing the production profile of single well heating.

Figure 7 is a cross-sectional view of solvent recovery in single well heating.

DETAILED DESCRIPTION

A well is drilled into the target formation. The entire operation may be achieved in a vertical well, slant well, horizontal well or an irregular well having a combination of vertical, horizontal and tilted portions to adapt to the geometry of the formation. Even further, the horizontal well can be extended from the vertical well.

A single well is used to achieve a gravity driven bitumen or heavy oil production process. However, multiple wells may be heated and produced simultaneously or sequentially, each with their own heat string. The well is cased to the bottom of an intermediate casing, where the horizontal section includes a thermal casing and thermal cement. In the horizontal section, the well has a liner with either slotting or screens to control any sand influx.

As shown in Figure 1, a string of tubing 2 is placed into the hole down through the vertical section and out into the horizontal section to a desired length. Then, the tubing 2 subsequently curls back to return along the horizontal run and back to the surface 4. The tubing 2 can be fully insulated, partially insulated, or non-insulated.

The tubing 2 contains a heating medium 6 which could be electricity, steam, or another fluid with high-heat transfer characteristics. At the surface 4, the electricity, steam, or fluid is reheated to the target temperature and then returned to the portion of tubing string 2 in the well. The electricity, steam, or fluid is at super-heated or saturated steam condition as it enters the well bore so that it transfers heat to the horizontal section. This initial preheating of the formation creates and initiates a depletion chamber. Condensing may take place and, because of the phase change and fixed volume, a thermo-siphon effect will be created.

After the preheating step, a solvent is introduced into the well. Preferably, in the horizontal section of the well, the solvent is added through an additional tubing string. Preferably, the solvent is a straight chain hydrocarbon which is easily vaporized at the well temperature and is miscible with the reservoir bitumen/oil. More preferably, the solvent is a light hydrocarbon such as butane, iso-butane, pentane, hexane or a mixed solvent with similar commercial diluents with a composition from C3 to C8, but the bulk of the solvent volume in the C5-C7 range. Experiments have shown that xylene and natural citric acid may also be used as solvents. Varying the solvent composition over time may be helpful from heavier C7 to lighter C3 over the production cycle. It should be kept in mind that the solvent composition must be matched to the specific reservoir operating conditions, ensuring a good vaporization and condensation temperature that matches the down hole temperature.

As shown in Figures 2 and 3, an initial fill of solvent in the horizontal well bore should be sufficient to maintain the process. When the liquid solvent reaches the tube heated by steam, the heat of condensation is released to the solvent. The solvent quickly heats to its boiling point and vaporizes. Since vapor is lighter and has a lower density than the liquid phase, solvent vapor will rise in the well bore filling the depletion chamber. The vapor will rise until it reaches a surface that is cool enough to condense it. Generally, the cooling surface will be the bitumen above the cased well. Once the vapor is condensed onto or with the bitumen, a hydrocarbon mixture is created and the viscosity and density of the mixture are much lower than bitumen alone but higher than pure solvent. The hydrocarbon mixture will flow by gravity down to the horizontal section of the well, creating a void space above in the reservoir. The lighter hydrocarbon mixture falls into the horizontal section of the well bore and meets with the heat of the steam tubing again. This causes the solvent portion of the mixture to evaporate and rise into the void space in a new cycle. At the same time, the bitumen in the well bore is maintained at a warm temperature, which keeps it mobile.

As shown in Figure 4, the mobile bitumen can be recovered from the horizontal well by means known in the art. For example, a gas lift or electric submersible pump system 12 can be used to lift the hot bitumen to surface. Preferably, the heat source is positioned at ground level. However, it may be also positioned down hole, as when using a standard ESP (electric submersible pump) which generates a significant amount of heat in the pumping action. Furthermore, an electric heating source can be used alone or in combination with other heating sources.

Based on the reservoir characteristics, if the proper solvent composition and operating conditions are used, the solvent will stay in the reservoir throughout the process without the need to top up the solvent. This results in little or no solvent in the production fluid because the

solvent remains a working fluid within the reservoir. The solvent has a repeating cycle consisting of being warm liquid in the horizontal section to hot vapor rising through the reservoir to a bitumen/solvent mixture flow back to the horizontal section. Because the solvent remains a working fluid in the reservoir, there is no solvent recovery until the end of the process resulting in less solvent used in the overall process.

Because there is minimal solvent injection in the process, energy is conserved because solvent recovery at the surface isn't typically needed. Even if the bitumen recovered contains trace or small amounts of solvent, the solvent remaining in the bitumen results in a slightly reduced viscosity and density, lowering any requirement for diluent additions prior to sales or pipelining.

As depicted in Figures 5 and 6, the bitumen produced from this process will still contain some water, since there is connate water entrapped around the sand grains in the reservoir along with the bitumen. However, the volume of water in the well will be substantially lower. In fact, the 300% volume of water in the bitumen volume experienced in typical SAGD operation is reduced to 15-30% volume of water in the bitumen volume.

Shown in Figure 7, upon depletion of the bitumen formation, the solvent remaining inside the formation can be cooled, drained to the bottom of the well, and recovered from the well for future reuse.

As is seen from above, important advantages of this process include the following:

- 1) Production costs will be significantly lower than traditional CSS or SAGD processes. Because there is no added water, the water doesn't have to be lifted to surface, cleaned, and reused or disposed. Likewise, there is no need to vaporize water for the steam injection into the reservoir.
- 2) The environmental impact of the operation will be much lower than traditional CSS or SAGD since there is no heavy water usage.
- 3) Using and cycling a contained heated fluid can maintain the well bore at very low pressures. This feature allows recovery of deposits which are very close to the surface and too complicated or even dangerous (in terms of potential steam release to the surface) for SAGD or CSS processes. The amount of resources suitable for this specific technology is huge in the Athabasca region alone, and is almost unexplored internationally.
- 4) The process described above can be equipped with additional machinery and equipment used in the enhanced oil recovery such as an oil treating facility, water treating facility, heaters, oil storage, power generating and pumping equipment known in the art.

As many changes therefore may be made to the preferred embodiment of the invention without departing from the scope thereof. It is considered that all matter contained herein be considered illustrative of the invention and not in a limiting sense.

We Claim:

1. A bitumen recovery process comprising the following steps:
 - a) Drilling a single well into a bitumen deposit;
 - b) Equipping said well with a heating element, a solvent injecting member, and a bitumen recovering member;
 - c) Injecting said well with a solvent having a low flash point through said solvent injecting member;
 - d) Heating said solvent with the said heating element to a vapor state while keeping the temperature and pressure in the well at a predetermined condition;
 - e) Mixing said solvent vapour with bitumen in the deposit thus reducing said bitumen viscosity;
 - f) Draining said bitumen to the bottom of the well proximate the heating element;
 - g) Heating the bitumen to keep its viscosity low, enabling recovery of the bitumen by bitumen recovering member;
 - h) Evaporating at least part of solvent entrapped in the bitumen at the bottom of the well by the heating element;
 - i) Recovering said bitumen and traces of water from the well by said bitumen recovering member;
 - j) Condensing said solvent inside the well for further mixing with the bitumen in the deposit;
 - k) Repeating steps h through j, wherein the majority of said solvent does not leave the well during the bitumen recovery process.
2. The process of claim 1 wherein the heating element utilizes electricity, steam, or a hot fluid circulating through the well.
3. The process of claim 2 where said electricity, steam, or hot fluid circulate through the well in a tube.
4. The process of claim 3 where the tube is insulated or partially insulated.
5. The process of claim 2 where the electricity, steam, or hot fluid are reheated at the surface.

6. The process of claim 2 where the electricity, steam, or hot fluid are reheated in the bore of the well.
7. The process of claim 1 wherein the solvent is pure light hydrocarbon solvent.
8. The process of claim 6 where the pure hydrocarbon solvent comprises propane, butane (normal, iso & mixed), pentane (normal, iso & mixed), or hexane (normal, iso & mixed).
9. The process of claim 1 wherein the solvent is a mixed solvent with composition from C3 to C8.
10. The process of claim 1 wherein the solvent is a mixed solvent with composition from C5 to C7.
11. The method of Claim 8 and 9 where the solvent composition is a heavier C7 in the initial recovery process and is progressively replaced with lighter hydrocarbons as the process continues.
12. The process of claim 1 wherein there is steam injected into the well along with the solvent.
13. The process of claim 1 wherein the produced fluids recovered from the well are primarily bitumen or heavy oil with a small amount of miscible contained solvent and some connate water.