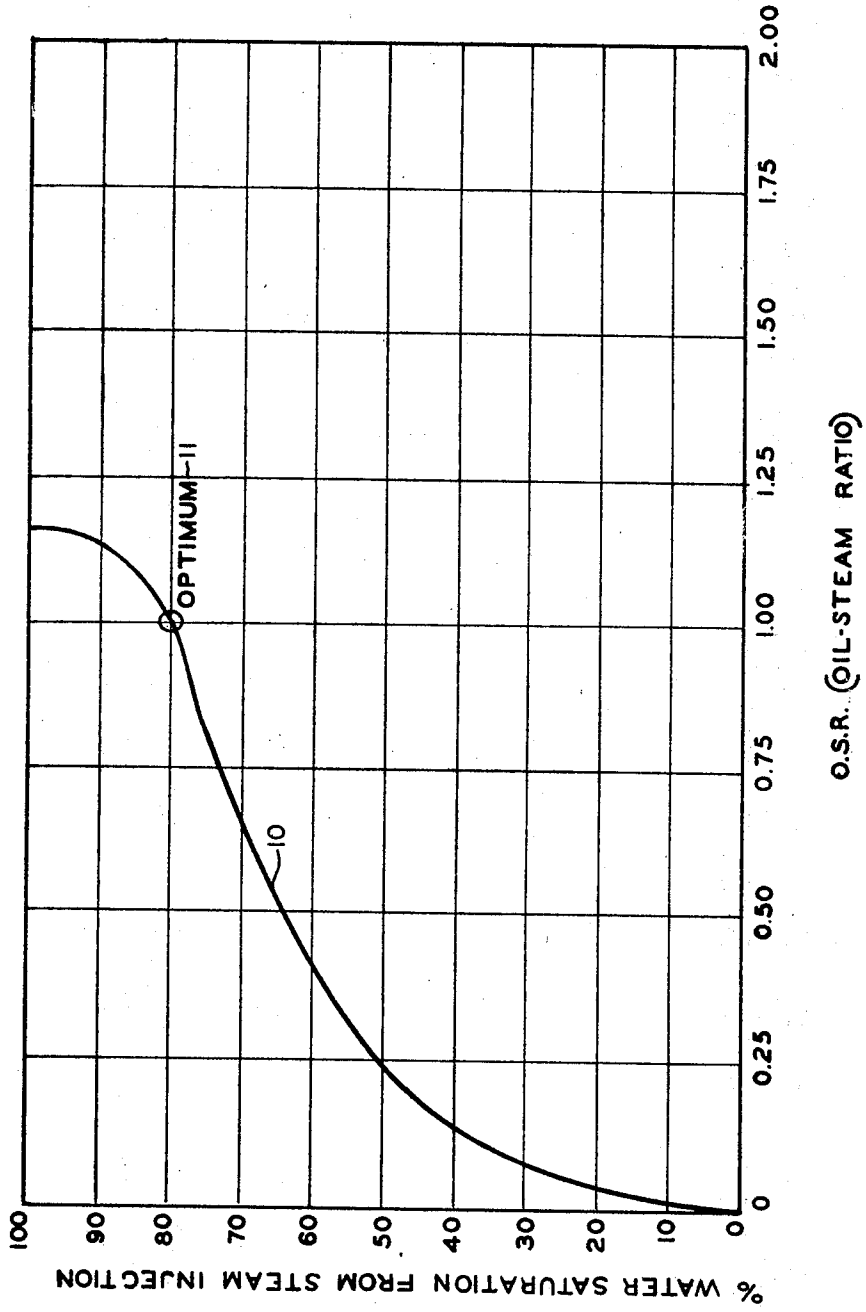
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STEAM INJECTION METHOD FOR PRODUCING OIL

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STEAM INJECTION METHOD FOR PRODUCING OIL

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ABSTRACT OF THE DISCLOSURE

The method of steam injection and producing a hydrocarbon bearing formation penetrated by a well bore to achieve optimum steam soak. The method includes injecting a predetermined quantity of water as steam into the well bore followed by logging of the well bore to determine the percent of liquid saturation of the formation adjacent the well bore. Thereafter oil is produced from the formation for a predetermined period of time and the quantity of oil produced is compared with the amount of oil recovered. The foregoing steps are repeated with the saturation level of the formation being increased to an optimum level where the rate of increase of units of oil recovered per unit of water injected as steam starts to decline.

This invention relates to a method of steam injecting and producing a hydrocarbon bearing formation penetrated by a well bore to achieve optimum steam soak. More particularly, this invention relates to a method of determining optimum steam soak cycle in a steam injection process for the recovery of oil from the formation.

Certain formations have heavy oil deposits, as for example some in California which are readily adaptable to steam stimulation treatments. One of the unknown factors is the length of time needed or the amount of water (as steam) required to adequately treat a formation.

Prior methods for judging the size of steam slugs are trial and error or based on experience. For example, a particular well penetrating a formation is given a steam treatment and a productivity thereafter determined. An adjacent well is thereafter injected with a smaller or larger slug of steam and the productivity thereof compared with the first well. This trial and error method may be continued until some optimum level of saturation is determined, but the results are an inexact method of measurement resulting in error in many instances.

It is therefore an object of this invention to provide an improved method of steam injecting and producing a hydrocarbon bearing formation penetrated by a well bore to achieve optimum steam soak.

It is also an object of this invention to provide an improved method for obtaining the optimum steam soak for one well penetrating a formation and applying the optimum steam soak level to adjacent wells penetrating the formation.

Briefly stated, this invention is for a method of steam injecting and producing a hydrocarbon bearing formation penetrated by a well bore to achieve optimum steam soak. The method includes the steps of injecting a slug of steam of a predetermined amount into the formation. Thereafter the formation is logged to measure the percent of fluid saturation thereof. Hydrocarbons are then produced from the formation for a predetermined period of time. These steps of injection, logging, and producing are repeated at least until the liquid saturation of the formation adjacent the well bore reaches a level where the rate of increase of hydrocarbons recovered per unit of steam injected starts declining. This optimum level is established by comparing the quantity of oil produced during the production step with the quantity of steam injected during the injection step.

In certain embodiments of the invention, adjacent well bores penetrating the formation may also subsequently be steam injected until the liquid saturation of the formation adjacent thereto reaches a saturation level at least equal to the optimum saturation level for the first well, and the producing oil from the other well bores.

Reference to the drawing will further explain the invention:

The drawing is a graph on which is plotted on the horizontal axis numbers representing the ratio between the units of oil produced to the units of water (as steam) injected during the injecting cycle.

The vertical axis shows the percent of liquid or water saturation of the well bore as the steam injecting steps are repeated. The curve designated by the numeral **10** is a typical curve for a well bore treated in accordance with the teaching of this invention, with the optimum point **11** showing the point at which the rate of increase of units of oil recovered per unit of steam injected starts to decline, which point will sometimes hereinafter be referred to as the optimum liquid saturation level.

In carrying out the teachings of this invention, let it be assumed that a hydrocarbon bearing formation, such as a heavy oil bearing formation such as those found in California, is penetrated by plurality of spaced apart well bores.

One of the well bores may be selected as the test well and initially logged to determine the liquid saturation of the oil bearing formation adjacent thereto. This logging may measure either hydrocarbon and/or water saturation.

Thereafter, a predetermined quantity of water as steam is injected into the test well and into the oil bearing formation to thereby heat the same. Then either during or subsequent to said injecting step, the well bore is logged again to measure the fluid saturation of the formation. Then oil is produced from the formation for a predetermined period of time. The quantity of oil produced during the production step is compared with the quantity of steam projected during the injection step.

The foregoing steps are repeated until the liquid saturation of the formation adjacent the test well bore reaches an optimum level. This optimum level is the point at which the rate of increase of units of oil recovered per unit of water as steam injected into the test well starts declining.

The line **10** on the drawing is a plot of steam induced water saturation and the amount of oil recovered per barrel of steam injected. Thus, there is established an efficiency and economic perimeter. The more oil recovered per barrel of steam injected the better the economics. An optimum is shown at point **11** whereafter a small additional increment of oil would be recovered while increasing the induced water saturation an additional 20 percent. From an economic standpoint, the additional oil recovered may not have a value equivalent to the cost to inject the additional steam, plus the delayed income from not placing the well back on production in a shorter length of time, plus the incremental cost to separate the additional water from the oil and the surface treating facilities. Based on the localized proven results in the test well, the other adjacent well bores are then steam injected to the optimum saturation level established for the test well.

It is to be understood that the method of logging the well bore contemplated by this invention may be with a conventional logging tool which is arranged to measure the liquid saturation thereof either in terms of hydrocarbons and/or water saturation. Hence, there is provided a method of determining optimum steam soak cycle in a "huff and puff" steam injection process. There is thus provided a method designed to provide rapid, accurate measure of oil and/or water saturation to prescribe the size of a steam stimulation treatment to be administered to a

given well and ultimately to the entire formation. Prior to injecting steam, a logging tool capable of measuring hydrocarbon and/or water saturation in a reservoir may be run and the initial oil and/or water content determined. The reservoir may then be steamed, allowed to soak and logged again. After being placed on production, the well is logged again. By logging and determining the oil and/or water saturation, optimum steam and soak cycles can be determined.

It is to be understood that any conventional logging technique (electrical, nuclear, or the like) is acceptable, if it is possible to determine fluid saturations therefrom. A one well test should establish optimum saturation levels at different cycles of treatment. Any method of saturation measurement is acceptable as long as it is possible to log during, or immediately following, the steam injection cycle of the "huff and puff" process.

It is to be understood that the examples discussed above are merely illustrative of the invention.

What is claimed is:

1. The method of steam injecting and producing a hydrocarbon bearing formation penetrated by a well bore to achieve optimum steam soak, said method comprising the steps of:

injecting a slug of steam of a predetermined amount into said formation;

logging said formation to measure the percent of fluid saturation thereof;

producing hydrocarbons from said formation for a predetermined period of time after said injection step;

repeating said injection, logging and production steps;

and continuing said repeating of said steps at least until the liquid saturation of said formation reaches a level where the rate of increase of units of hydrocabons recovered per unit of steam injected starts declining.

2. The method of determining optimum steam soak cycle in a steam injection process for the recovery of oil from a formation, the combination of steps comprising:

injecting a predetermined quantity of water as steam into said formation through a well bore penetrating said formation;

logging said bore to determine the percent of liquid saturation of said formation adjacent said well bore;

producing oil from said formation through said well bore for a predetermined period of time;

comparing the quantity of oil produced during said production step with the quantity of steam injected in said injecting step;

and continuing repeating said injecting, logging, producing and comparing steps at least until the liquid saturation of said formation adjacent said well bore reaches an optimum level where the rate of increase of units of oil recovered per unit of water injected as steam starts declining.

3. The invention as claimed in claim 2 including the additional steps of:

injecting steam into a plurality of other well bores penetrating said formation until the liquid saturation of the formation adjacent each of said other well bores reaches a saturation level at least equal to said optimum saturation level established for said first well bore;

and producing oil from said other well bores.

4. In a method of steam-injecting and producing a hydrocarbon bearing formation penetrated by a plurality of well bores to achieve optimum steam soak, the combination comprising the steps of:

injecting a slug of steam of a predetermined amount into said formation through one of said well bores;

logging said one well bore to measure the percent of fluid saturation thereof;

producing hydrocarbons from said formation through said one well bore for a predetermined period of time after said injection step;

repeating said injection, logging and production steps;

continuing said repeating of said steps at least until the liquid saturation of said formation reaches an optimum level where the rate of increase of units of hydrocarbons recovered per unit of steam injected starts declining;

injecting steam into said other well bores until the liquid saturation of said formation adjacent thereto is at least equal to the optimum liquid saturation of said one well bore;

and producing hydrocarbons from said other well bore after said steam injecting.

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