METHOD FOR INJECTING HEATED FLUIDS INTO MINERAL BEARING FORMATIONS

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ABSTRACT OF THE DISCLOSURE

Heated fluids are injected into mineral bearing formations while flowing electrical current through tubing through which the fluids are injected at a rate to produce heat in the tubing sufficient to prevent loss of heat by the fluids while moving through the tubing.

BACKGROUND OF THE INVENTION

The present invention relates to the recovery of minerals from sub-surface formations more particularly to method for injection of heated fluids in the subsurface formations for treating same.

It is oftentimes desirable to treat a subsurface formation with heated fluids. For example, sulphur is most commonly mined by injecting heated water into the sulphur bearing formation for the purpose of melting the sulphur and permitting it to flow to the surface. One of the methods for treating paraffin blocks in the production of oil is to inject hot oil into the formation. Hot water, steam and heated gases are often injected for repressuring petroleum bearing formations. However, a definite limitation has been placed on the depth at which formations can be treated with heated fluids because of loss of heat of the fluids into the strata above the desired formation as the fluids flow through tubing from the surface to the formation of interest. Thus, because of the above-mentioned cooling effect, it is generally not considered feasible to produce sulphur by the Frasch process at depths below 1500 feet. Similarly, efforts to treat oil bearing formations with heated fluids such as oil, gas or water at depths in excess of 2000 feet are generally not economical.

SUMMARY OF THE INVENTION

In accordance with the method of the present invention, a well bore is drilled which extends from the surface into a mineral bearing formation positioned below other formations. At least one tubular member of electrically conductive material is positioned in the well bore. The fluids to be injected into the formation are heated and caused to flow through the tubular member into the mineral bearing formation while causing current to flow through the tubular member for generating heat and reducing loss of heat from the heated fluids into strata above the mineral bearing formation.

In accordance with the preferred embodiment of the invention, the tubular member is position within a string of conductive casing, but electrically insulated therefrom except at its bottom portion. Accordingly, the path of the flow of current will be down the tubular member to the mineral bearing formation, thence up to the conductive casing. If desired, the tubular member can be made of material having a resistivity to provide the desired amount of heat. This is most often necessary when the mineral bearing formation is at relatively shallow depths. Alternatively, high resistance sections can be provided in the tubular member producing additional heat at the high resistance portions.

Many objects and advantages of the invention will become apparent to those skilled in the art as a detailed description of the preferred embodiment of the invention unfolds in conjunction with the appended drawings wherein like characters denote like parts and in which:

FIG. 1 is a side elevation view diagrammatically illustrating a well bore penetrating the earth surface into a mineral bearing formation; and

FIG. 2 is a side elevation view similar to FIG. 1, but only showing the lower portion of an installation in accordance with a second embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

There is shown in FIG. 1 of the drawings a well bore 10 which penetrates the earth into a mineral bearing formation 12. One or more strata 14 are positioned between the mineral bearing formation 12 and the surface 16 of the earth. Typically, among the formations penetrated by the well bore would be a formation 18 containing cold water. A string of casing 20 is positioned in the well bore 10 and extends from the surface to the mineral bearing formation 12. In the specific example of the invention shown, an open hole completion is contemplated and the casing 20 only extends partially into the formation 12 whereas the well bore 10 suitably extends through the formation. Concrete 22 is suitably forced into the formation above the mineral bearing formation and around the casing 20 for the purpose of insulating pipe or restricting any tendency for the wall of the well bore to cave into the mineral bearing formation and for holding the casing 20 in place.

Threadedly connected to the upper part of the string of casing 20 is a flange 24, suitably one formed of an insulating material. There is also provided an insulating flange member 26 which supports a string of insulating pipe 30. A string of conductive tubing 33 is supported by yet a third flange member 27, also suitably of insulating material. The three flange members 24, 26 and 27 are connected into a unitary structure by a plurality of bolts 30 and nuts 32. The lower portion 34 of the string of tubing is electrically connected to the lower portion 36 of the string of casing 20 by suitable means such as a centralizer 38 formed of conductive material. It will be noted that the well head structure comprising the flanges 24, 26 and 27 in combination with the string of tubing 33 and return through a path including casing 20 and the connecting member 38.

The string of tubing 33 is connected to a tank 50 through a valve 52 and a pump 54. The tank 50 suitably contains fluid to be injected into the formation 12 and associated therewith is a heater 56 for heating the fluids to the desired temperature. There can also be provided a second tank 58 which is connected to the string of tubing 33 at pump 60 and valve 62. The tank 58 and its associated pump 60 and valve 62 would only be provided, however, if it was desired to also remove fluids from the formation through the tubing 33. It will be noted in this regard that the pump 60 is effective when operated to produce a flow of fluids from the tubing 33 into the tank 58 whereas the tank 54 when operated will produce a flow of...
fluids from the tank 50 into the tubing 33. In accordance with the method of the present invention, the valve 62 and the valve 52 are closed and the pump 34 is operated until such time as the fluids within the tank 50 were heated to a desired temperature by the heater 56. Electrical current is then caused to flow through the tubing 33 in casing 20 to produce heat. In this connection, it is preferred that the source of supply of voltage be connected to the conductors 40 and 42 through a transformer 70 having a plurality of taps 72 in order that the potential impressed across the circuit comprising the casing 20 in the tubing 33 can be varied. Also, the string of tubing can include one or more sections 74 of higher resistivity material in order to increase the resistance of the current path. As a greater amount of heat will be produced in the vicinity of the joints of high resistivity material, these can preferably be positioned in the vicinity of water bearing sand such as the sand 18 or other strata having high coefficient of thermal conductivity.

The valve 52 is opened and the pump 54 operated to cause heated fluids to flow from the tank 50 into the mineral bearing formation 12. Heat produced in the string of tubing 33 and the string of casing 20 as a result of flow of electrical current will effectively reduce the loss of heat from the heated fluids into the formations above the two bearing formations. As 54 and 60, it would not be possible for the heated fluids from the tank 50 to arrive at the mineral bearing formation 12 at substantially the same temperature as that at which the fluids left the tank 50. It is important to note, in this regard, that when conventional installations are used for injection of heated fluids into subsurface formations that substantially no benefit will be obtained if the formation is more than 2000 feet deep as the temperature of the fluids reaching the formation will be substantially at formation temperature.

If an installation as shown in FIG. 1 is used, essentially all of the electrical energy will be converted to heat in the tubing as the casing becomes part of a conductor of indefinite area (the earth). The amount of heat which would be lost by the fluid if heat were not provided can easily be computed and the applied voltage controlled to provide the desired amount of heat.

In order to reduce the amount of heat required, the tubing 33 can be thermally insulated from the formation 14 by applying thermal insulation to the casing or tubing or by centering the tubing 33 and pipe 28 with spacer 76 and sealing the annulus with packer 78 and 80 to provide air spaces with a minimum of contact area.

The installation of FIG. 1 can be modified as shown in FIG. 2. Thus, it is feasible to insulate the tubing 33 from the casing 20 by using spacers 90 of insulating material and filling the annulus 92 above packer 94 with an insulating fluid. Further, if it is desired to provide heating in the formation 12 as well as the casing 20, a path for flow of current through the formation can be provided by providing a length of insulating casing 96 at the lower end of the string of casing or by extending the tubing 33 below the insulating pipe 28 with the insulating pipe 28 extending below the casing 20. By controlling the length of the joint 96 of casing or the distance the insulating pipe extends below the casing, the resistance of the current path in the formation can be varied to control the amount of heating in the tubing and the formation. Such a procedure is especially useful in the treatment of formations containing paraffin base oils.

Although the invention has been described with reference to a particular preferred embodiment thereof, many changes and modifications will become apparent to those skilled in the art in view of the foregoing description which is intended to be illustrative and not limiting of the invention defined in the appended claims.

What is claimed is:

1. The method of treating a subterranean mineral producing formation wherein a well bore extends from the surface into a mineral bearing formation positioned below other formations comprising the strata, providing sections in a tubular member having a higher electrical resistivity than the remainder, positioning at said tubular member in said well bore extending downward from the surface into the mineral bearing formation and flowing heated fluids through the tubular member from the surface into the mineral bearing formation while causing electrical current to flow through said tubular member for generating heat and reducing loss of heat from said heated fluids into the other formations above said mineral bearing formations.

2. A method as defined in claim 1 wherein the sections are positioned adjacent strata having a high coefficient of thermal conductivity.

3. A method as defined in claim 1 further including the step of thermally insulating said tubular member from the other formations.

4. The method of treating a subterranean mineral producing formation wherein a well bore extends from the surface into a mineral bearing formation positioned below other formations comprising the strata, positioning at least one tubular member in said well bore extending downward from the surface into the mineral bearing formation while causing electrical current to flow through said at least one tubular member for generating heat and reducing loss of heat from said heated fluids into the other formations above said mineral bearing formation and controlling the flow of electrical current to control the heat produced in said tubular member to be substantially equal to the heat which would be lost by the heated fluids in the absence of heating of the tubular member.

5. A method as defined in claim 4 further including the step of simultaneously heating the tubing and the mineral bearing formation adjacent said well bore.

6. A method as defined in claim 4 further including the step of thermally insulating said tubular member from the other formations.

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