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TREATMENT OF WATER WELLS USING A SATELLITE WELL

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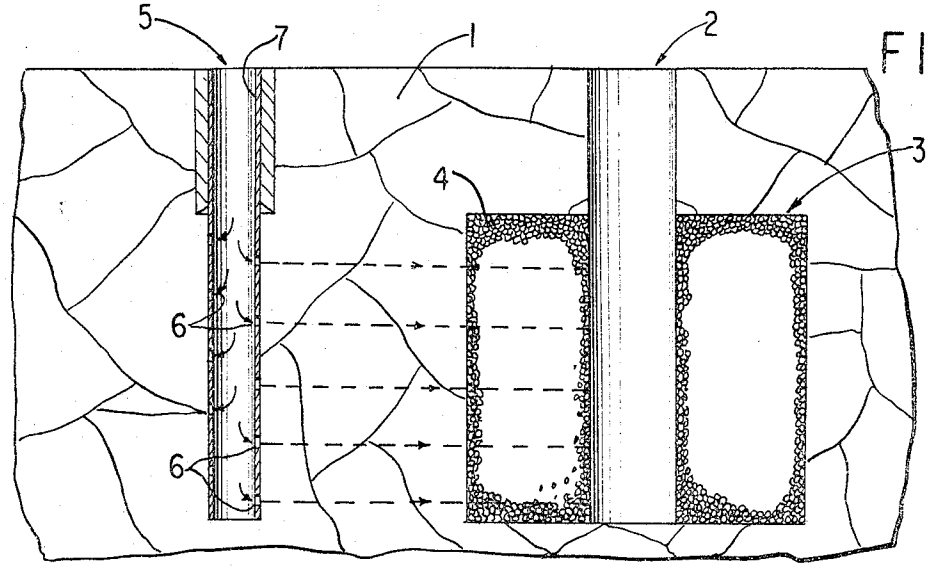


FIG. 1

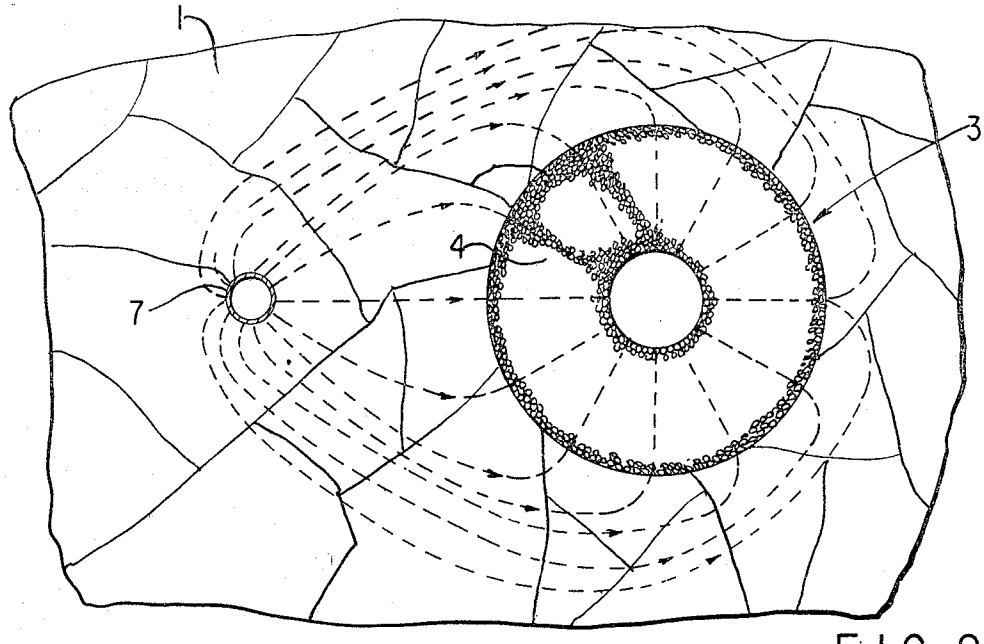


FIG. 2

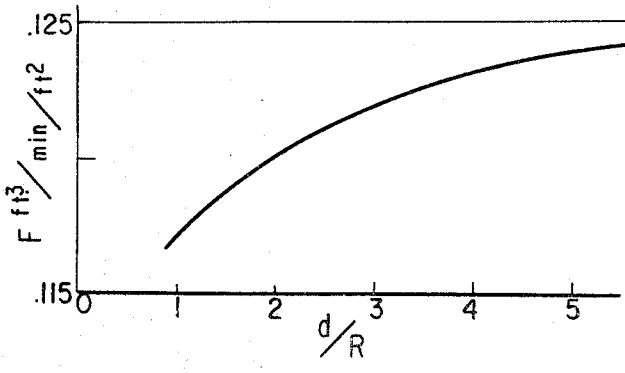


FIG. 3

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TREATMENT OF WATER WELLS USING A SATELLITE WELL

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ABSTRACT OF THE DISCLOSURE

Treating fluid is injected into the producing formation in the vicinity of the wellbore of a water well. The treating fluid is injected through a satellite well that can be positioned so that all points on the periphery of the production wellbore and its adjacent formation area can be contacted by the desired quantity of the injected treating fluid. Any suitable treating fluid may be employed. Interruption of pumping operations and repacking of the gravel in the production wellbore are avoided.

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to the treatment of water wells. More particularly, it relates to an improved method for the removal of matter obstructing the flow of water from a producing formation into the wellbores of water wells.

Description of the prior art

Water wells often undergo a decline in productivity due to factors other than the exhaustion of the producing formation. Well waters commonly contain minerals that precipitate in the producing formation and in the gravel pack of the production wellbore itself. Such minerals include calcium sulfate and carbonates and various salts of magnesium and iron. The precipitation of these mineral deposits tends to clog the flow channels into the production well, thereby diminishing the productivity of the water well. In addition, the producing formation and the gravel pack of the production wellbore are commonly contaminated by finely divided organic material that is accompanied by bacteria. These bacteria and other minute and often harmful organisms also tend to clog the flow channels so as to decrease the permeability of the gravel pack in the production wellbore and the adjacent producing formation. Productivity of the water well is thereby diminished.

In order to improve the productivity of water wells by removing mineral deposits and accumulations of bacteria, various clean-out processes, acid treatments and bactericide treatments have heretofore been proposed. Thus, various acids, such as sulfuric acid and hydrochloric acid, have been injected into the production wellbore in order to remove clogging matter and to increase the productivity of water wells. This procedure, of course, necessitates the interruption of the water pumping operation and the removal of the water pump from the producing interval of the production wellbore. In many instances, it has also been necessary to replace the gravel pack in the production wellbore before resuming pumping operations. Such treatments, furthermore, have been only moderately successful in accomplishing the desired results. One reason for the limited success of such prior art techniques is believed to be the inability of the treating fluid to adequately reach all parts of the affected wellbore and the adjacent producing formation.

It is an object of the present invention, therefore, to provide an improved process for the treatment of water wells.

It is another object of this invention to provide a process for improving the productivity of water wells.

It is another object of the present invention to provide a process for the treatment of water wells in which said treatment may be accomplished without interrupting water pumping operations.

It is a further object of the present invention to provide a water well treating process that obviates the need for replacing the gravel pack in the production wellbore undergoing treatment.

It is a further object of the present invention to provide a water well treating process in which all portions of the production wellbore and the adjacent producing formation may be contacted with the desired quantity of treating fluid.

SUMMARY OF THE INVENTION

The objects of the present invention are accomplished by a process in which the desired treating fluid is injected into the producing formation through a satellite well positioned in the vicinity of the production well. The treating fluid thus injected into the producing formation is drawn through the producing formation and the production wellbore so as to accomplish the desired contacting of the treating fluid with the mineral deposits and the bacteria-containing organic material clogging the flow channels into the production well. The desired treating fluid is injected into the water-bearing producing formation while pumping operations are continued so that the pressure differential in the producing formation between the point of injection and the production wellbore tends to draw the treating fluid through the formation to the production wellbore. The treating fluid will thus follow the natural flow distribution pattern from the point of injection to the production wellbore.

The productivity of water wells can be improved, to varying degrees, by injecting the desired treating fluid into a satellite well positioned at any convenient distance from the production wellbore. It is particularly advantageous, however, to assure that the entire area around the production wellbore, including the adjacent producing area, is exposed to contact by the desired amount of treating fluid for effective treatment of the prevailing condition in the producing formation and in the production wellbore. Such a result may be achieved by positioning the satellite well at a particular approximate distance from the production wellbore. The determination of this positioning of the satellite well is within the scope of the present invention as hereinafter set forth in detail.

BRIEF DESCRIPTION OF THE DRAWING

The invention is hereinafter described with reference to the accompanying drawing in which:

FIGURE 1 is a side elevation view, partly in cross section along line **1—1** of FIGURE 2, of the producing formation and the production wellbore, and showing the general positioning of the satellite well.

FIGURE 2 is a top view, partly in cross section along line **2—2** of FIGURE 1, showing the flow pattern from the satellite well to the production well.

FIGURE 3 is a graph showing the ratio of the distance between the satellite well and the radius of the production wellbore for various flow conditions at a point on the periphery of the wellbore diametrically opposite the position of the satellite well under a particular set of operating and formation conditions.

DETAILED DESCRIPTION OF THE INVENTION

Water wells are treated, in accordance with the present invention, by injecting the treating fluid into the producing formation through a satellite well positioned apart from

the production well being treated. The treating fluid is injected into the satellite well while pumping operations are in progress at the production wellbore. Thus, the pumping operations need not be interrupted, and the pump need not be removed from the production wellbore during the treating process of the present invention.

The particular fluid employed in the treatment of a given production well is not a critical feature of the present invention. Any known chemical or combination of chemicals may be employed in the practice of the invention. Likewise, the present invention is not limited to the treatment of any particular condition in the formation and in the production wellbore. The present invention, to the contrary, may be employed in the treatment of any prevailing condition adversely affecting the productivity or other characteristics of water wells. It relates not to a specific treatment of a specific condition, but to the manner in which any known treating fluid may be effectively utilized for the treatment of any given undesired condition.

The present invention, therefore, may be employed with respect to the use of treating fluids for the removal of a variety of undesirable materials from the producing formation and the production wellbore. If the reduced productivity of a water well results from the presence of inorganic solids in the formation and in the gravel pack of the production well, the treating fluid will commonly be a solution of hydrochloric or sulfuric acid. Such acids are commonly employed in conventional techniques for the dissolving of inorganic materials, such as calcium carbonate and various salts of magnesium and iron. In accordance with the present invention, the treating solution, e.g. a HCl solution of from about 2% to about 28% concentration, may be injected through a satellite well into the producing formation in the vicinity of the production wellbore.

Various treating agents have been disclosed in the art for the destruction of bacteria in production wellbores. For example, common bleaching powder, known as "high-test hypochlorite" and "perchloron," having the formula $Ca(ClO)_2$, may be employed in the treatment of various bacteria such as *Gallionella ferruginea*.

It is within the scope of the present invention to inject the desired treating fluid or fluids into the producing formation periodically through a satellite well in predetermined quantities sufficient to control or overcome the clogging condition. A given quantity of treating fluid may, for example, be injected into the satellite well every six months for the treatment of a reoccurring clogging condition. The quantity of the treating fluid that must be employed for the effective treatment of the particular clogging condition will generally be known or can be readily determined by those skilled in the art as is done with respect to the treatment of water wells by conventional techniques.

The satellite well may be positioned in the vicinity of and at any convenient distance from the wellbore of the water well being treated. While the distance between the satellite well and the production well is not critical, it will readily be appreciated by those skilled in the art that certain operating conditions will tend to set practical limitations upon the positioning of the satellite well. The satellite well will not, for example, ordinarily be positioned so that the distance between the injection well and the production well is less than the radius of the production well. If the satellite well were so positioned, the injected fluid would flow rapidly through the gravel pack, which has a relatively high permeability, and would not adequately contact the producing formation adjacent to the production well and, in particular, the interface between the producing formation and the production well. It is in this area near the interface of the producing formation and the gravel pack that a significant amount of organic and inorganic clogging material is believed to accumulate. For this reason, the satellite well will ordinarily be positioned so that its distance from the center of the production well is at least greater than the radius of the production well. The treating fluid will thus contact a greater portion of the at least partly clogged formation adjacent to the interface between the producing formation and the gravel pack in the production wellbore.

While the productivity of the production well will be increased to some extent regardless of how far removed the satellite well is positioned in the producing formation from the production well, it will be appreciated that the satellite well should not be positioned so far from the production well that a "diverting anomaly" would be interposed between the production well and the satellite well. By a "diverting anomaly" is meant an anomaly, such as a vertical fracture, that would tend to divert the treating fluid from its intended flow path from the satellite well to the production well. If such an anomaly were to be interposed between the satellite well and the production well, the treating fluid injected into the satellite well would, quite obviously, be diverted into portions of the formation other than the portion that it was intended to contact.

While the distance between the satellite well and the production well is not critical and may be varied widely between practical limits, the satellite well may conveniently be positioned so that the ratio of the distance between the center of the satellite well and the center of production wellbore to the radius of the production wellbore is between about 3 and about 5. It is advantageous to position the satellite well so that the injected treating fluid will adequately contact a specified portion of the area adjacent the production well and the corresponding portion of the production wellbore. A particularly desirable treatment would be one in which the producing formation and the gravel pack in the production wellbore around the entire periphery of the production well is treated with a desired minimum quantity of the treating fluid. This beneficial result may be accomplished by a particular placement of the satellite well with respect to the production well being treated.

The satellite well may be positioned, in accordance with the present invention, so that the producing formation and the gravel pack adjacent a point on the production wellbore diametrically opposite to the position of the satellite well may be contacted by a desired quantity of the treating fluid for effective treatment of the clogging condition. The approximate distance between the center of the satellite well and the center of the production wellbore to achieve this result is expressed by the formula:

$$d = R\left[\frac{2Q}{\frac{4\pi RF}{C\phi}+3q}-1\right]$$

where d is the distance between the center of the satellite well and the center of the production wellbore, in feet; R is the radius of the production wellbore, in feet; Q is the injection well strength, in ft.^{3} atm./min. ft.; F is the desired quantity of treating fluid for effective treatment at a point on the periphery of the production wellbore diametrically opposite the position of the satellite well, in ft.^{3}/min./ft.^{2}; C is the compressibility of the treatment fluid, in l./atm.; q is the average producing strength of the production well, in ft.^{3} atm./min. ft.; and ϕ is the porosity of the producing formation, expressed in percent. This formula provides a convenient means for determining the proper location for a satellite well in order to achieve the desired amount of treatment at a point on the periphery of the production wellbore diametrically opposite to the position of the satellite well itself. Due to the natural flow distribution pattern through which the injected treating fluid passes from the satellite well to the production well, all other points around the periphery of the production wellbore will be contacted by at least as large a quantity of treating fluid as the point

diametrically opposed to the position of the satellite well. By proper positioning of the satellite well, therefore, the entire producing formation area around and adjacent to the production well, as well as the entire area of the gravel pack in the wellbore, may be treated with the desired amount of treating fluid.

The strength of the injection and production wells, as applied in the formula above, is determined by the respective injection and production flow rates and the characteristics of the formation being treated. Thus,

$$Q=\frac{\text{treatment injection rate, in gal./min.}}{7.48\phi\ Ch}$$

and

$$q=\frac{\text{production rate, in gal./min.}}{7.48\phi\ Ch}$$

where h is the thickness of the water producing zone, in feet.

Referring to FIGURE 1 of the drawing, the producing formation is represented generally by the numeral **1**. Production well **2** located therein has a wellbore **3** in which gravel pack **4** is placed. Satellite well **5** is positioned in the vicinity of production well **2**. Injection ports **6** are provided in satellite well casing **7** so as to permit injection of the treating fluid at various elevations in producing formation **1**.

As best shown in FIGURE 2, the treating fluid follows the natural flow distribution patterns from the point of injection in satellite well **5** to production well **2**. The treating fluid thus contacts producing formation **1** in the area all around producing well **2**. In addition, the treating fluid passes through gravel pack **4** to the production well casing from which it is pumped to the surface by conventional pumping means, not shown. For a given set of formation conditions and for a given injection rate, positioning of the satellite well at the position called for by the application of the formula given above will assure that the desired amount of treating fluid is available for effective treatment at a point on the periphery of production wellbore **3** diametrically opposite the position of satellite well **5**. Positioning satellite well **5** closer to production well **2** will result in an increase in the flow of the treating fluid directly into production well **2** with a corresponding decrease in the amount of treating fluid carried by the natural water distribution pattern to the opposite side of production well **2**. Positioning satellite well **5** further away from production well **2** will, on the other hand, likely result in some effective loss in treating fluid because of the expanded flow distribution pattern that would exist with respect to such further removed points of injection.

In order to illustrate an additional use for the formula given above, the formula was rearranged in the following manner:

$$F=\frac{C\phi}{4\pi R}\left[\frac{2Q}{1+d/R}-3q\right]$$

Values of F were calculated as a function of the ratio d/R with reference to a particular water well application in which the radius of the production well was 2.5 ft. and the average producing capacity of the production well was approximately 1,000 gal./min. The porosity of the water producing zone, which was 100 ft. in thickness, was 25%. The contemplated treating fluid injection rate was 250 gal./min. The compressibility of the treating fluid was $3(10)^{-6}$/p.s.i.

The values of F, the flow or flux into the water well at a point diametrically opposite the satellite well, at various values of the ratio d/R were as set forth in the following table and as shown graphically in FIGURE 3 of drawing.

TABLE

F:	d/R
0.117	1
0.1202	2
0.1221	3
0.1232	4
0.1239	5

As can be seen from FIGURE 3, a minimum desirable value for the ratio d/R to obtain a flux (F) approaching the limiting amount obtainable at a point on the production wellbore diametrically opposite the position of the satellite well appears to be approximately 3.0. By positioning the satellite well at least 7.5 ft. from the center of the production well in this instance, therefore, the flow into the wellbore at a point diametrically opposite the position of the satellite well may be maximized.

The invention has been described heretofore with respect to satellite wells positioned so that the natural flow distribution pattern causes the injected treating fluid to pass from the satellite well to the production well. It is also within the scope of the present invention to position one or more satellite wells at points outside the natural flow pattern into the production well being treated. Such wells may be employed separately or in combination with satellite wells positioned in the natural flow pattern. In one embodiment, for example, satellite wells can be placed at 90° intervals around the production well being treated. With respect to satellite wells positioned outside the natural flow pattern, it will readily be appreciated that relatively high injection and production flow rates may have to be employed so as to facilitate the flow of the treating fluid from the satellite well to the production well being treated.

The present invention, as previously indicated, permits pumping operations to be continued during the treatment of water wells. The permeability of the gravel pack in the wellbore and the adjacent producing formation may be improved by reaction of a treating fluid injected into the producing formation through a satellite well and drawn through the producing formation, in part at least, by the pumping operation itself. The productivity of the treated water well can thereby be significantly improved. Since the pumping apparatus positioned at the producing interval in the production wellbore is not removed during the treating operation, the gravel need not be repacked as is sometimes necessary in prior art techniques. To the contrary, the gravel pack around the entire periphery of the production wellbore may be contacted by a sufficient quantity of the treating fluid to effectively remove soluble inorganic deposits and bacteria that tend to clog the pores, crevices and flow channels in the gravel pack. The present invention provides a particularly useful means for treating the interface between the gravel pack and the adjacent producing formation, an area in which undesirable mineral deposits and bacteria growth are likely to occur so as to diminish the productivity of the water well. In addition to an appreciable saving in operating time and expense, therefore, the present invention also permits a very satisfactory contacting of the treating fluid with the material obstructing flow into the water well, thus enhancing the value of the treatment.

While the present invention has been described herein with reference to particular embodiments thereof, it will be readily appreciated by those skilled in the art that various changes and modifications can be made therein without departing from the scope of the invention as set forth in the appended claims.

Therefore, I claim:

1. A process for treating production water wells having an undesired condition comprising contacting the producing formation adjacent to at least one of said production wells with a treating fluid capable of removing the undesired condition by injecting the treating fluid into said producing formation through at least one satellite well positioned in the vicinity of the production well, the

approximate distance, in feet, between the center of the satellite well and the center of the production wellbore being expressed by the formula:

$$d=R\left[\frac{2Q}{\frac{4\pi RF}{C\phi}+3q}-1\right]$$

where R is the radius of the production wellbore, in ft., Q is the strength of the injection well, in ft.^{3} atm./min. ft.; F is the desired flow of treating fluid for effective treatment at a point on the periphery of the production wellbore diametrically opposite the position of the satellite well, in ft.^{3}/min./ft.^{2}; C is the compressibility of the treatment fluid, and l./atm.; q is the average producing strength of the well being treated, in ft.^{3} atm./min. ft.; and ϕ is the porosity of the producing formation, in percent, whereby said treating fluid is drawn through the producing formation to the production wellbore by the pressure differential in the producing formation between the point of injection at the satellite well and the production wellbore so that the treating process may be carried out without interruption in water pumping operations and without the necessity for repacking the gravel in the production wellbore upon completion of the treating operation.

2. The process of claim **1** in which the producing formation is at least partially clogged and the treating fluid is capable of removing the clogging material, whereby the productivity of the production well being treated is increased.

3. The process of claim **1** in which the satellite wells are positioned in the natural flow distribution pattern, whereby the pressure differential existing in the producing formation tends to draw the injected treating fluid to the production wellbore.

4. The process of claim **3** and including the injection of a portion of the treating fluid through at least one satellite well positioned outside the normal flow distribution pattern into the production well, the injection and production flow rates being such that the injected fluid will tend to flow to the production well being treated from both the satellite wells positioned in the natural flow pattern and those that are outside said natural flow pattern.

5. The process of claim **1** in which said satellite wells are positioned outside the normal flow distribution pattern into the production well, the injection and production flow rates being such that the injected fluid will tend to flow from the satellite wells to the production well.

6. The process of claim **1** in which the distance between the center of the production wellbore and the center of the satellite well is at least greater than the radius of said production wellbore.

7. The process of claim **6** in which the satellite well is so positioned that it is between the production wellbore and any anomaly that would tend to divert the treating fluid from its intended flow path from the satellite well to said production wellbore.

8. The process of claim **1** in which said satellite well is positioned so that the treating fluid flow distribution pattern is such that the point on the periphery of the production wellbore diametrically opposite to the position of said satellite well is contacted by the desired amount of treating fluid for effective treatment.

9. The process of claim **1** in which the treating fluid is injected into said producing formation through the satellite well periodically in order to control the clogging condition over an extended period of time without interruption in water pumping operations.

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