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SHUTTING OFF WATER IN OIL WELLS

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This invention relates to shutting off water in oil wells; and it comprises a method of differentially shutting off the flow of water into an oil well penetrating oil and water formations, without substantially affecting the flow of oil into the well, wherein a solution of a normally solid plastic material in a difficultly vaporizable liquid of limited solubility in water is forced into the well and caused to travel through the interstices in the water-bearing formation, whereby slow solution of the liquid in water occurs with deposition of the solid; all as more fully hereinafter set forth and as claimed.

Water and oil often occur together in the producing formations adjacent an oil well. They often occur in closely contiguous parallel strata or sand layers, and in many cases both flow into the well at about the same point. Satisfactory methods have been developed for shutting off all flows into a well, as by cementing the well with hydraulic cement or concrete, but no satisfactory method is in use for selectively shutting off the water without affecting the oil. The present invention provides a useful process for selective water shutoff.

In the differential shutting off of the flow of water into the well without permanent interference with the oil flow, it is desirable to deposit material forming a precipitate in the interstices of the water sands, but it is advantageous that the deposit be made at a point as remote as possible from the well. This is for the reason that material in the exposed face is readily forced out by pressure whereas it is not readily forced out when occurring at a point further into the formation; the pressure differential there being not so great.

In the present invention, this object is secured by injecting into the well and the surrounding formation a difficultly vaporizable liquid of limited solubility in water and carrying a dissolved plastic material; that is a crystalline solid, semi-solid or gummy substance, not soluble in water. After the solution is deposited in the sand, the well is allowed to flow. The solvent is gradually taken up by the flowing water leaving the plastic material in place. A number of solutions are suitable for the present purposes. One such solution is produced by dissolving sulfur in aniline. Aniline is somewhat soluble in water and after the solution has been forced outward to the desired distance, and the well allowed to flow, the aniline slowly dissolves in the water and is removed. Insoluble sulfur is left in the water sands, sealing them. Similar treating solutions can be prepared by dissolving sulfur in the butanols, in the amyl alcohols, in phenol and in cresol. Commercial cresylic acid is satisfactory. All these liquids are of relatively high boiling point or low vaporizability and hence present no difficulties in handling and injecting into the well. All have a limited solubility in water. The low rate of solution allows the liquid containing the dissolved solid to be forced a considerable distance into the surrounding formations, while deposition of the solid material is delayed. If the solid came out of solution immediately on contact of the solution with water, it would be difficult to force the solution into the well to any great distance, because a filtering face would be formed at or near the bore walls in the early stages of the injecting operation.

Sulfur is not the only normally solid material which can be used in this way. In some cases it is desirable to employ substances of greater solubility in oil than sulfur. For example, in situations where some water occurs in the oil sands it is desirable to use a material which is readily dissolved by oil, so that any deposition in the oil sands is dissolved and flushed out by the oil during well production. Naphthalene or common resins are more readily soluble in oil than is sulfur, and can be used to advantage in my process in certain cases. Other useful substances of this type include stearic acid, certain heavy salts of organic acids, etc. These substances are used in conjunction with an appropriate solvent of the type described. The resulting solutions may have densities greater or less than that of water or well brines. The well treatment is modified depending on whether the treating solution is more or less dense than the well waters. When the solution employed has a density less than, or approximately the same as that of water or the well brine the well should be pumped free of water before the solution is injected. For example, a saturated solution of stearic acid in isoamyl alcohol has a specific gravity of 0.815 at 77° F. and contains 9.43 pounds stearic acid per 100 pounds alcohol. In treating a well with this solution, brine can be first removed from the well by pumping it out. The solution is then injected.

In case it is desired to avoid the necessity for pumping out, a somewhat modified procedure can be followed. The treating solution can be introduced into the well on top of the brine column and pressure applied, to force first the brine and then the solution into the water formation. For example, a solution of sulfur in aniline, contain-

ing 1.5 parts by weight of sulfur per 100 parts aniline, has a specific gravity of 1.023. The solution can be floated on the brine column in the well, and pressure applied, which forces the brine and then the solution into the formation. Swabbing is not strictly necessary when the density of the treating solutions is markedly greater than that of the well waters. For instance, using the sulfur in aniline solution described in a well flowing substantially fresh water with specific gravity around 1.00, the solution can be injected directly without removing water from the well.

I can introduce directly into a well, after preliminary bailing or swabbing, a solution of calcium or magnesium naphthenate in cresol. Pressure is then applied to the well to force the solution into the surrounding formation, and the well is allowed to flow. Gradual deposition of the solid matter occurs as the cresol is slowly dissolved out by the water flow.

In a specific embodiment of the invention a well producing oil and water is treated to shut off the water without materially influencing the flow of oil. A batch of treating solution is made up by dissolving 150 pounds sulfur in 10,000 pounds aniline, using heat to accelerate the solution. The solution has a specific gravity of 1.023. Water and oil standing in the well are pumped out. The batch of liquid is forced into the well under pressure sufficient to make it penetrate a substantial distance into the producing formations; sand in this case. After forcing in the solution as far as possible the well is permitted to flow. The flow of water gradually takes the aniline in solution, leaving the sulfur behind to plug the pores. After treatment, the flow of water into the well is found to be stopped or materially reduced, while the oil flow is unaffected.

In another specific embodiment of the invention, a well producing oil and water and containing a column of saline water is treated to shut off the water. In this case it is desirable to avoid the necessity of bailing or swabbing. A batch of treating solution is made up by dissolving 500 pounds calcium naphthenate in 10,000 pounds cresol, with heating. The solution has a specific gravity of 1.018. The batch of solution is pumped into the well under pressure. It floats on the column of brine in the well. The brine and the solution are forced consecutively into the producing formations under pressure, as far as possible; the practical limit being reached when the pump pressure rises above the range which can be conveniently provided. The well is allowed to flow. The flow of water slowly dissolves and removes the cresol, leaving the water insoluble calcium naphthenate deposited in the water formation. Calcium naphthenate being soluble in oil, any of this material incidentally deposited in the oil formation is flushed out when the well is allowed to flow. After treatment the oil produced by the well is found to be substantially unaccompanied by water, showing that the water formation is practically stopped.

In most cases the matter deposited from the treating solution on dilution with water comes out as an amorphous precipitate of more or less gummy nature. This is desirable, since the deposited substance tends to flow slightly under influence of water pressure in the water formation, sealing the interstices even more effectively. Moreover the amorphous deposits are more voluminous than corresponding crystalline deposits.

What I claim is:—

1. The process of retarding the flow of water from crude petroleum wells which consists in forcing into the producing formations a solution of a plastic water insoluble substance in a difficultly vaporizable liquid which is readily soluble in oil and sparingly soluble in water, said solution being inert to oil and not tending to form non-liquid masses therewith, then permitting the well to flow.

2. A method of differentially shutting off flow of water into an oil well having water and oil formations adjacent the well without substantially hindering the flow of oil into the well, wherein a solution of a normally solid plastic material in a difficultly vaporizable liquid of limited solubility in water is forced into the well and into the formations surrounding the well, said solution being inert to oil and not tending to form non-liquid masses therewith, and the well is allowed to flow so as to dissolve and remove the liquid, leaving the solid deposited in the water-bearing formations but not in the oil-bearing formation.

3. The matter of claim 1 wherein the plastic substance is sulfur and the liquid is aniline.

4. The matter of claim 1 wherein the plastic substance is stearic acid and the liquid is isoamyl alcohol.

5. The matter of claim 1 wherein the liquid is an organic solvent and the solid plastic material is an organic solid.

6. The matter of claim 1 wherein the solid material is soluble in oil.

7. The matter of claim 1 wherein the density of the solution is greater than that of water.

8. The matter of claim 1 wherein the density of the solution is less than that of water.

9. A method of differentially shutting off flow of water into an oil well having water and oil formations adjacent the well without substantially affecting flow of oil into the well, wherein water and oil standing in the well are removed, a solution of a normally solid plastic material in a difficultly vaporizable liquid of limited solubility in water is forced into the well and the producing formations adjacent the well bore, said solution being inert to oil and not tending to form non-liquid masses therewith, and the well is allowed to flow, the flow of water dissolving away the liquid, leaving the solid deposited in the water formations but not in the oil formations.

10. A method of differentially shutting off the flow of water into an oil well having water and oil formations adjacent the well without substantially affecting the flow of oil into the well, the oil well containing a column of water, wherein a solution of a normally solid plastic material in a difficultly vaporizable liquid of limited solubility in water is introduced into the well above the water column, said solution being inert to oil and not tending to form non-liquid masses therewith, and pressure is applied to force the water and the solution into the water formation, in turn, and the well is allowed to flow so that the water gradually dissolves away the liquid from the water strata leaving the solid deposited therein.

11. The matter of claim 10 wherein the solution comprises a naphthenate of a metallic base dissolved in cresol.

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