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METHOD OF TREATING OIL WELLS TO PREVENT WATER CONING

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3 Sheets-Sheet 1

FIG. 1

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FIG. 2
METHOD OF TREATING OIL WELLS TO PREVENT WATER CONING

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ABSTRACT OF THE DISCLOSURE

The existence of water coning is eliminated or prevented in oil producing wells by separately fracturing the formation in the oil producing zone and the transition zone of oil and water and in the water zone, cementing the middle fracture, and injecting a gas through the lower fracture. The gas may be injected between or during periods of oil production.

This invention relates to the treatment of oil wells. More particularly, this invention relates to the method of treating wells drilled in underground oil formations which are contiguous to underground water formations to control the amount of water present in the recovered oil. Still more particularly, the present invention relates to a method of treating oil wells to overcome water coning and to increasing oil production.

In many oil fields, the oil producing formation is found in a contiguous relationship to a substantially water-saturated, water producing formation. Under static, non-producing conditions the water having a greater density is found beneath the oil producing formation. During production, however, a pressure drop is formed near the well, causing both oil and water to flow radially toward the well bore. The small difference in density and large difference in viscosity between the water and the oil gives rise to upwardly directed pressure gradients around the well. This difference in pressure causes the water to rise to a substantial height above the normal or static oil-water interface and forms conical column around the well bore within the normal oil producing region. This phenomenon is known as water-coning. The result of water-coning in a producing well is a rise in the water to oil production ratios, a consequent lowering of oil production, an increase in the cost of lifting the oil, an additional expense incurred in separating the water from the oil, an increase in corrosion problems and expense of water disposal. As production continues, the water level rises even further and the water cone grows in size. Eventually a point in the production history is reached when production of oil from the well is no longer economical.

Several methods of suppressing water-coning in oil wells have been suggested. One method involves reducing the depth of the oil well and recovering oil only from the top of the formation. This method often unduly restricts oil recovery and is not considered a satisfactory solution, especially in formations having thin oil pay zones. Another method is to bottom the well in a formation substantially impermeable to water. However, many wells do not have the water-impermeable formation necessary for this method. Other methods comprise depositing cement in the well bore adjacent the water-producing formation up to the water-oil interface. These methods have not been found effective to minimize or greatly reduce water-coning as the water continues to intrude into the oil producing region. Still other methods comprise forcing gas and sealing materials into the water producing zone. With these methods, the sealing material often intrudes into the oil zone thereby reducing the oil production rate. In addition, it has also been suggested to fracture the well at the oil-water interface and to fill the fracture with a water impermeable cement early in the production history. However this procedure at best only slows down the formation of a water cone and has been found very difficult to adopt as it is usually not possible to position the fracture in the well with the degree of accuracy required.

Accordingly, it is an object of this invention to provide an improved method for increasing oil production from underground formations.

Further, it is an object of this invention to decrease the water/oil production ratio of a well having both water and oil producing formations.

Still further, it is an object of this invention to provide an improved method of overcoming water-coning in oil wells having both water and oil producing formation.

Still further, it is an object of this invention to increase the oil production of a well having both water and oil producing formations while overcoming water-coning.

These and other objects of the invention will become apparent from the following disclosure wherein reference is made to the figures of the accompanying drawings.

FIG. 1 schematically illustrates the phenomenon of water-coning.

FIG. 2 schematically illustrates a well which has been fractured in accordance with the present invention.

FIG. 3 schematically illustrates the method of the present invention in operation.

In accordance with the present invention oil production is increased and water-coning is overcome by the use of selectively positioned horizontal fractures in combination with gas injection. If the well to be treated is undergoing production, the production is halted, then a first horizontal fracture is formed in the oil producing zone by any conventional fracture forming technique. Similarly, a second fracture is then formed which extends radially into the water-oil transition zone. This is the area occupied by the upper portion of the water cone. This second fracture is filled with an impervious material such as cement using recognized cementing techniques so as to form a cemented fracture which will act as a barrier to the vertical movement of fluids. A third fracture is made in the water producing zone below the cement filled fracture. Either the first fracture or the third fracture or both may be filled with a suitable propping agent, for example, metal pellets, glass beads, sands, or shells, to insure a steady fluid flow through these fractures. A packer is then installed within the well casing to divide it into an upper section communicating with the oil zone and a lower section communicating with the water zone. A tube is extended through the packer and into the lower portion of the well. Gas is forced under pressure, down the tubing and into the lower portion of the well. The pressurized gas leaves the well bore by way of the lowest fracture which extends into the water zone. As it leaves the area of the well bore the gas permeates through the surrounding sands displacing the water in a downward and outward direction from the well. The low density of the gas causes it to rise but the impermeable cemented fracture acts as a barrier to this upward travel and causes the gas to move away from the well pushing the water into the more remote areas of the formation. Above the cemented zone the gas moves toward the well bore thereby depressing the water cone and displacing oil into the oil zone fracture. Any of the gas not entering the oil zone fracture rises to the top of the oil formation until it encounters the cap rock. There the gas collects forming a pocket beneath the rock and in doing so displaces oil downward, in the manner of a gas driven injection well, toward the oil zone fracture.
Another portion of the gas rises to the top of oil formation 3 and collects under cap rock 2. The pressure exerted by this pocket of gas 19 serves to force additional oil into the well via fracture 8.

Although the practice of this invention has been described in terms relating to the preferred embodiment of overcoming water coning in a well that has developed a high water/oil ratio through production, the order of steps taken according to the present invention may be altered so as to provide for inhibition of water coning in newly formed wells.

With a newly formed well, fracture 10 may be formed and cemented at or slightly above the water/oil interface before production. The formation of the cemented fracture at that time will aid in inhibiting the rise of a water cone. Likewise fracture 8 may be formed at any time before or during the production history to enhance the flow of oil and reduce pumping pressure.

Furthermore, the present invention is also applicable to producing wells which may have one or more of the fractures required by the method already formed. To apply the present invention to these wells, the wells are further fractured, divided into upper and lower portions by a packer and gas is injected into the lower portion.

In any case, treatment of wells by the present invention may be practiced intermittently whenever the water/oil ratio rises to an undesirable level or in a continuous manner simultaneously with production.

As will be apparent to those skilled in the art, many substitutions, alterations and omissions are possible without departing from the spirit or scope of the present invention.

What is claimed is:

1. A method of treating a well having both oil producing and water producing zones to overcome water-coning which comprises, forming a first fracture in the oil producing zone, form- ing a second fracture in the water/oil transition zone, cementing said second fracture, forming a third fracture in the water producing zone, dividing the well into an upper portion communicating with said oil zone and a lower portion communicating with said water zone, and injecting a gas under pressure into said lower portion.

2. The method of claim 1 wherein the first fracture, or the third fracture, or both are filled with a propping agent.

3. The method of claim 1 wherein oil recovery from the well is halted before the formation of the fractures and is resumed after injection of the gas.

4. The method of claim 3 wherein gas injection continues after oil production is resumed.

5. The method of claim 3 wherein the injection of gas is halted before oil production is resumed.

6. The method of claim 1 wherein the gas is air.

7. The method of claim 1 wherein the gas is a gaseous mixture of combustion products.

8. The method of claim 1 wherein the gas is natural gas.

References Cited

UNITED STATES PATENTS

2,368,424 1/1945 Reistle 166-42 X
2,784,787 3/1957 Matthews et al. 166-42 X
2,788,855 4/1957 Peterson 166-42
2,832,416 4/1958 Allen 166-42
3,052,499 5/1962 Brown 166-42 X
3,134,438 5/1964 Hultz et al. 166-42 X
3,228,470 1/1966 Papalia 166-42 X
3,237,690 3/1966 Karp et al. 166-42 X
3,297,088 1/1967 Hultz et al. 166-42 X

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