

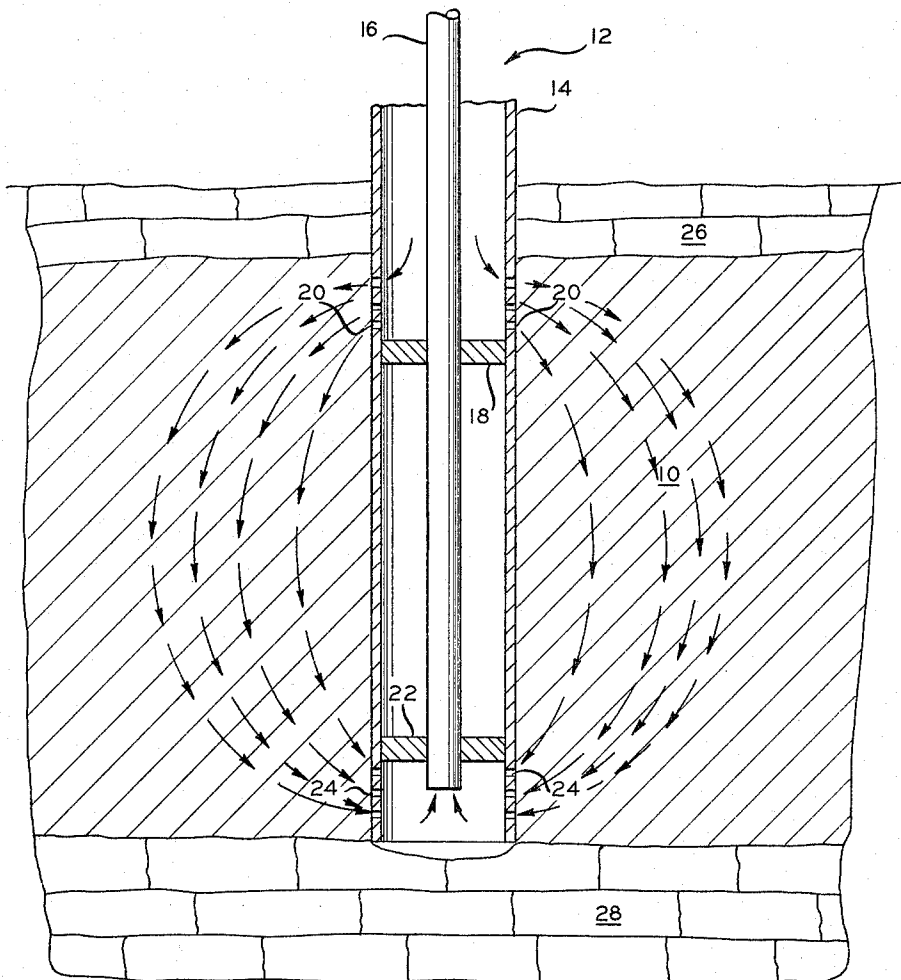
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REMOVAL OF WATER BLOCKS FROM OIL AND GAS WELLS

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REMOVAL OF WATER BLOCKS FROM OIL AND GAS WELLS

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This invention relates to a process for removing a water block around a hydrocarbon-producing well.

In the production of oil and gas from a producing well in a hydrocarbon-bearing stratum, the zone around the well bore sometimes develops a condition of reduced permeability which results in a decrease in production of hydrocarbon from the well. One cause of this reduced permeability is the accumulation of water in the producing formation in the region adjacent the well bore. This water accumulation, conventionally designated "water block," may be due to injected water, as from drilling or workover operations or to interstitial water gradually migrating from deep in the formation to the area adjacent the well bore. One method commonly proposed for the removal of such a water block comprises injecting into the blocked stratum a water-miscible solvent, with or without certain additives, to effect solubilization and displacement of the water. However, this method is rather ineffective in most instances in view of the fact that the proposed technique displaces the water in the water block deeper into the formation. Later when production is resumed the water returns to block the well again.

This invention is concerned with a method of effectively overcoming the water block problem.

Accordingly it is an object of the invention to provide an effective process for removing a water block around a hydrocarbon-producing well. Another object is to provide a process which alleviates water occurrence or water block adjacent a well bore and which increases the production of hydrocarbons from a well. Other objects of the invention will become apparent upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises forcing a driving fluid through the annular section of stratum containing a water block around a producing well so as to drive the water from the annulus into the well. The annulus of the well between the tubing and casing is packed off in an upper level of the stratum and a second packer is set at a lower level of the stratum between the tubing and casing. The casing is of course perforate within the producing stratum so that fluids may pass to and from same, from and into the well bore. The driving fluid is injected either through the tubing into the stratum or through the casing-tubing annulus into the stratum. When following the former technique, the driving fluid passes into a lower section of the stratum, upwardly through the annular section of stratum containing the water block, and drives the produced water into the casing-tubing annulus above the upper packer. Following the latter technique, the injected driving fluid enters the stratum above the upper packer and passes downwardly through the annular section of stratum containing the water block so as to produce the water from the annulus into the well bore below the lower packer where it is readily produced through the tubing.

Any driving fluid may be utilized in the process but it is preferred to utilize a water-miscible solvent as at least a substantial portion of the driving fluid. The driving fluid may be gaseous or liquid. Driving fluids in gaseous form include air, carbon dioxide, flue gas, natural gas, normally gaseous hydrocarbons, etc. Liquid driving fluids include water-miscible solvents including ketones such as acetone, methyl ethyl ketone, methyl propyl ke-

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tone, diethyl ketone, etc.; alcohols such as ethanol, methanol, n-propyl alcohol, isopropyl alcohol, n-butyl alcohol, secondary-butyl alcohol; ethers, particularly cyclic ethers, dioxane, tetramethylene oxide, furan, etc.; ether alcohols, such as methyl Cellosolve, Cellosolve, isopropyl Cellosolve, the carbitols, etc.; and esters such as butyl acetate, glycol diacetate, carbital acetates, and Cellosolve acetates. Most of the foregoing solvents are both oil and water soluble and have a favorable effect on the stratum containing water and oil. Other solvents conventionally used in the art are operable in the process. The injected solvent may also contain surfactants or wetting agents in small concentration such as about one weight percent of the solvent, more or less than this amount being useful. Any well known surfactants or wetting agents may be utilized such as the amines, trimethylamine or triethanolamine; esters including naphthalene sulphonic ester, oleic acid sulphate, oleo glyceryl sulphate; sulphonated oils such as sulphonated castor oil; or alkyl sulphates such as those commercially known as Gardinols. Other sulphates or wetting agents may also be used in the process.

In some instances it may be advantageous to employ, in conjunction with the water-miscible solvent, hydrocarbons such as liquefied petroleum gas, propane, butane, pentane, hexane, gasoline, Stoddard solvent, kerosene, crude oil, benzene, and toluene. The use of such hydrocarbons may be particularly advantageous for water-blocked oil wells where it may be desirable to dissolve and remove oil surrounding the water block as well as the water block itself. Furthermore, water encapsulated in viscous oil is more readily removed if the oil surrounding it is dissolved through use of a suitable hydrocarbon solvent.

The hydrocarbon may be employed as a solution in the solvent (ketone or alcohol) or it may be injected directly into the water-blocked formation so as to condition the formation for the subsequent injection of the solvent. It also may be injected prior to and during the injection of the solvent. It is preferable that the solvent or the solvent solution of hydrocarbon be preceded by hydrocarbon alone for removal of water blocks surrounded by oils having a gravity less than 20° API. The hydrocarbon solvent, by dissolving these viscous oils, greatly reduces the viscosity of the oil and promotes the release of encapsulated oil for subsequent solution in the water-miscible solvent. The aromatic hydrocarbons, such as benzene and toluene, are especially useful in this application of the invention, exhibiting high solvent power for the asphaltic constituents and other components of the viscous oils, thereby avoiding blocking of the formation. The very low cost of some of the hydrocarbons provides an added incentive for their use where applicable.

A more complete understanding of the invention may be had by reference to the accompanying schematic drawing which is an elevation through a producing stratum penetrated by a production well.

Referring to the drawing, a stratum 10, bearing oil and/or gas, is penetrated by a production well 12 containing a casing 14 and a tubing string 16. Casing 14 is perforated within stratum 10. Upper packer 18 is set below perforations 20 and lower packer 22 is set above perforations 24. Of course casing 14 and tubing string 16 extend through a conventional well head (not shown). A portion of the over burden is designated by numeral 26 and the substratum is designated by numeral 28.

When driving fluid is injected through the casing-tubing annulus, the driving fluid passes through perforations 20 into the upper section of the stratum and flows downwardly under injection pressure to perforations 24, thereby passing through a substantial annulus of the stratum

immediately surrounding the well so as to flush out or drive water from the water block into the well from which it is produced through tubing 16.

When utilizing the reverse technique, injection fluid is passed through tubing 16 into the bore hole below packer 22 and thence through perforations 24 and the annular section of stratum adjacent casing 14 from which the produced fluids pass through perforations 20 into the casing-tubing annulus from which production is effected through the well head.

After flushing or driving the water in the water block from the stratum into the well, the well is open to production so that the natural pressure of the formation drives oil and/or gas into the well for production therefrom. When opening the well to production, the packers 18 and 22 may be removed from the well in order to facilitate production.

When injecting a solvent such as an alcohol or a ketone, the solvent together with displaced water and some hydrocarbon is forced through the annular section of stratum surrounding the well and into the well through the perforations in the casing. If desired, the solvent and oil may be separately recovered from the effluent mixture. In the interest of economy, it is beneficial to periodically analyze the effluent and recycle the produced mixture through the water-blocked stratum when the mixture contains less than about 20 volume percent of extracted reservoir constituents. Injection of fresh solvent or recycling of the effluent mixture is continued until any remaining water in the produced annular section of stratum can be readily forced through the stratum into the well bore upon resumption of production.

EXAMPLE

Three laboratory displacement tests were made under conditions simulating those which might exist in attempts to remove water blocks from a zone around the well bore

having a porosity of 35.6 percent, a calculated pore volume of 112.5 cc., and a measured pore volume of 123.2 mm. This sand had an initial saturation of 83.6 percent oil and 16.4 percent water. A zone of high water saturation was created in the sand pack by injecting a volume of deionized water equal to about 20 percent of the hydrocarbon pore volume of the sand. An equal volume of methyl alcohol was then injected into the sand from the same end of the tube as used in injecting the water, followed by injection of Monagas crude oil into the other end of the tube, thus simulating the injection of methyl alcohol into a water-blocked formation and subsequent back-flow into the well bore as a result of the natural reservoir pressure. The high viscosity of the Monagas crude oil made measurement of the volume of the effluent rather difficult; therefore the volume of effluent was assumed to be equal to the volume of injected liquid. To determine the volume of the clear fluid portion of the effluent, i.e., the portion comprising water and methyl alcohol, Stoddard solvent was added to the effluent to dissolve the oil, and the volume of the clear liquid phase was then measured readily. The volume of oil in the effluent was then determined by a material balance calculation. The concentration of methyl alcohol in the clear fluid was determined by referring the density of the fluid to a previously obtained curve showing the density of water-methyl alcohol solutions of varying alcohol concentration.

The results of the three experiments are tabulated in Table I, which is divided into three parts representing the injection of water, methyl alcohol, and Monagas crude oil, respectively. Runs 1 and 2 were carried out with the sand-packed tube in a horizontal position. Run 3 was conducted with the tube in a vertical position, the water being injected from the bottom and the tube then being inverted, after which methyl alcohol was injected from the top, and crude oil was injected from the bottom.

Table I

WATER INJECTION PHASE

Run No.	Injection Rate, cc./hr.	Volume Injected, cc.	Pressure, p.s.i.g.		Produced Volume, cc.		Methyl Alcohol in Clear Fluid, Volume Percent
			Inlet	Outlet	Clear Fluid	Oil	
1-----	5.0	25.0	15.0	0	8.0	17.0	-----
2-----	3.5-5.0	25.0	15.0	5.0	8.5	16.5	0
3-----	1.0-2.0	25.0	5.0	0	10.0	15.0	Nil

METHYL ALCOHOL INJECTION PHASE

1-----	8.0-14.0	25.0	15.0	0	19.5	5.5	-----
2-----	10.0	25.0	15.0	5.0	20.0	5.0	Nil
3-----	1.0	25.0	5.0	0	20.0	5.0	Nil

OIL INJECTION PHASE

1-----	5.0	132.0	15.0	0	16.5	115.5	(¹)
2-----	5.0	130.0	15.0	5.0	17.0	113.0	89.0
3-----	1.0	100.0	5.0	0	(¹)	(¹)	85.5

¹ Value not available.

of one of the producing wells in Morichal Field, Monagas, Venezuela. These tests were designed to show the result of injecting a water-miscible solvent into a water-blocked formation, without the use of packers as required in the present invention, and subsequently removing the injection pressure, thus allowing the natural reservoir pressure to force the water-miscible solvent, and the water is displaced, into the well bore. The tests were conducted at 160° F. in a glass tube one inch in diameter and 24 inches long packed with Monagas sand

The results in Table I indicate that in each of the runs the methyl alcohol displaced the water ahead of it by a pistonlike action, essentially all the water being displaced from the tube upon completion of the alcohol injection. The back-flow of oil through oil injection, in turn, effected displacement of methyl alcohol from the tube. Thus there is some evidence that if methyl alcohol is injected into a water-blocked formation, without the use of packers as required in this invention, the water will be displaced deeper into the formation, and upon resumption of pro-

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duction, the methyl alcohol will be forced into the well bore, leaving the water in the formation to again act as a water block.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for removing a water block in a hydrocarbon-bearing stratum adjacent a producing well containing a casing having a perforate section within said stratum and a production tubing extending to a lower level of said stratum, said stratum having natural pressure and said water block being formed by migration of interstitial water from deep in said stratum toward said well during oil production, which comprises the steps of:
 - (1) setting a first packer within said stratum between said tubing and said casing at a lower level thereof;
 - (2) setting a second packer within said stratum between said tubing and said casing at an upper level thereof;
 - (3) passing driving fluid, other than water, thru an annulus of said stratum containing said water block between the packed off annulus above said second packer and the well bore below said first packer so as to drive water from said water block into said well bore;
 - (4) producing from said well the water driven thereinto by step (3);
 - (5) thereafter, allowing natural reservoir pressure to produce hydrocarbons into said well; and
 - (6) recovering said hydrocarbons from said well.
2. The process of claim 1 wherein said driving fluid is a gas.
3. The process of claim 1 wherein said driving fluid is a liquid.
4. The process of claim 1 wherein said driving fluid is a ketone.

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5. The process of claim 1 wherein said driving fluid is air.
6. The process of claim 1 wherein said driving fluid is carbon dioxide.
7. The process of claim 1 wherein said driving fluid is hydrocarbon.
8. The process of claim 1 wherein said driving fluid is natural gas.
9. The process of claim 1 wherein said fluid is injected thru the casing-tubing annulus into the upper section of said stratum just above said second packer and fluids driven from the annulus of stratum surrounding said well are produced into the well bore below said first packer.
10. The process of claim 1 wherein said driving fluid is injected thru said tubing so as to enter said stratum below said first packer and drive produced fluids into the tubing-casing annulus above said second packer.
11. The process of claim 1 wherein a liquid hydrocarbon is utilized in conjunction with a water-miscible solvent as driving and flushing fluid.
12. The process of claim 1 wherein at least a substantial portion of the driving fluid is a water-miscible solvent.
13. The process of claim 12 wherein said driving fluid is an alcohol of 1 to 4 carbon atoms.

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