

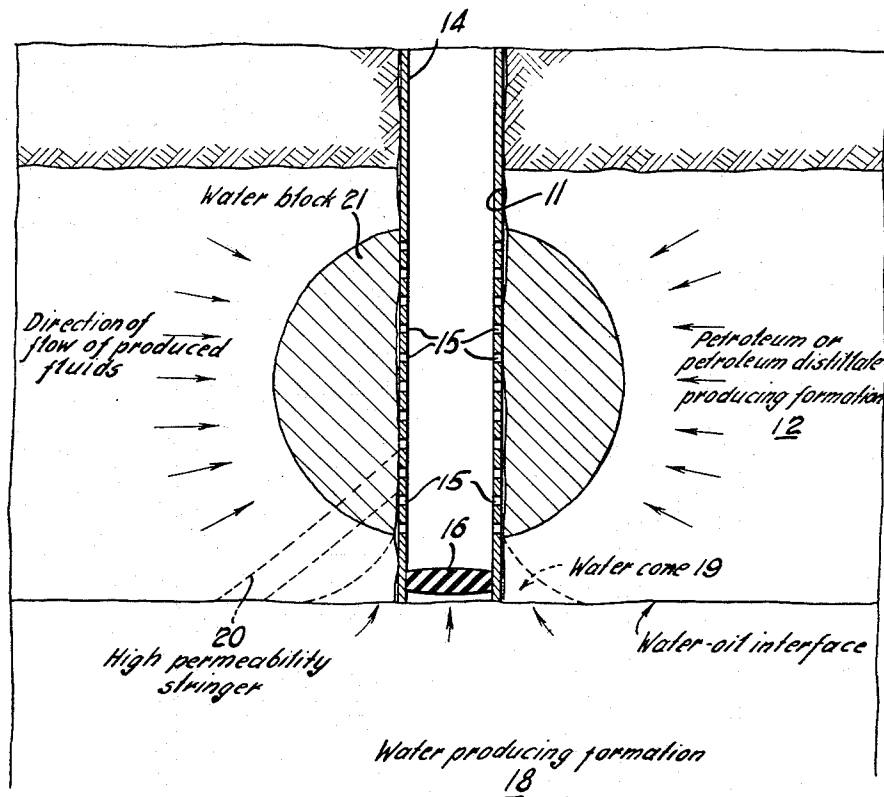
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## WELL TREATMENT TO REMOVE A WATER BLOCK

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## WELL TREATMENT TO REMOVE A WATER BLOCK

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This invention relates to the production of petroleum hydrocarbons from a subsurface reservoir. More particularly, this invention relates to the production of petroleum hydrocarbons, normally gaseous and/or normally liquid hydrocarbons, from a subsurface reservoir via a well bore penetrating said reservoir wherein water is simultaneously produced with said petroleum hydrocarbons. Still more particularly, this invention relates to a method for dispelling or removing a water block induced in a zone surrounding a well bore penetrating a formation from which petroleum hydrocarbons are produced.

In checking the production history of petroleum producing wells which produced water simultaneously with petroleum hydrocarbons it was observed that upon the resumption of petroleum production following the well loading up and dying, the rate of petroleum production therefrom fell off to a fraction of its previous rate. Usually efforts to restore these wells to their original petroleum production rate by conventional means were unsuccessful. It is believed that a zone surrounding the well bore within the petroleum producing formation became water blocked as a result of allowing the water column within the well bore comprising the water simultaneously produced with the petroleum hydrocarbons to fall back and saturate a zone within the petroleum producing formation in the immediate vicinity of the well bore. As indicated, such a water block is caused by the water column in the production flow string being allowed to fall back, either due to loss of flow or to shutting in the well temporarily, into the zone of production surrounding the well bore thus displacing oil from the immediate vicinity of the well bore and substantially saturating with water the petroleum producing formation in the immediate vicinity of the well bore thereby drastically reducing the permeability to hydrocarbons of that portion of the petroleum producing formation surrounding the well bore.

It is an object of this invention to provide an improved method of well treatment.

It is another object of this invention to provide an improved method for the removal of a water block from within a petroleum-producing formation in a zone surrounding a well bore penetrating the same.

Still another object of this invention is to provide a method for dispelling a water block which sometimes arises in a zone surrounding a well bore penetrating a petroleum producing formation when petroleum production from said formation is halted with the result that the column of well fluids comprising water within the well bore is dumped or permitted to flow back into the petroleum producing formation with the result that a zone surrounding said well bore within said petroleum producing formation becomes substantially saturated with water, thereby drastically reducing the permeability to hydrocarbons in said zone so that flow of hydrocarbons there-through is substantially nil.

It is still another object of this invention to provide a method of well completion.

How these and other objects of this invention are at-

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tained will become apparent with reference to the accompanying drawing which schematically illustrates a water block which block may be dissipated in accordance with the practice of this invention.

5 In accordance with this invention a water block within a petroleum producing formation in a zone surrounding a well bore penetrating the same is removed or dispelled by injecting into said water block via said well bore a petroleum fraction, preferably a liquid petroleum fraction having a viscosity substantially the same or about the same as that of water and admixed with a surfactant material which reduces the surface tension of water to lower the interfacial tension between water and the petroleum hydrocarbons, in an amount sufficient to dispel the water block and to dissipate the same outwardly from the well bore into the petroleum producing formation.

10 In accordance with one embodiment of the practice of this invention for the removal of a water block from a zone surrounding a well bore within a petroleum producing formation there is introduced into said zone via said well bore a liquid petroleum distillate fraction, such as a naphtha fraction, in an amount such that the volume of liquid petroleum fraction thus-introduced is at least substantially the same as the volume of said petroleum producing formation occupied by said water block. Immediately following the injection of said liquid petroleum distillate fraction, which may or may not be admixed with a surfactant material which reduces the surface tension of water, a gaseous medium is introduced into said zone at a rate and for a time sufficient to dispel said water block and to drive the water originally present within said water block outwardly from said well bore into said petroleum producing formation for a substantial distance thereinto. Following the above described treatment there is introduced into said zone via said well bore an additional amount of a petroleum distillate fraction preferably admixed with a surfactant material which reduces the surface tension of water. The amount of additional liquid petroleum fraction thus-introduced is usually a fraction of the liquid petroleum distillate first introduced into the water block, generally less than one half, frequently in the range one quarter to one twentieth. Following this second injection of the liquid petroleum distillate fraction there is introduced into said zone additional gaseous medium so as to sweep or otherwise remove or drive the remaining water within the zone thus-treated outwardly into the petroleum producing formation. As a result of the above-indicated treatment the water block originally surrounding the well bore in the zone of petroleum production is substantially completely dispelled or dissipated. When this treatment has been carried out petroleum production can be resumed and original petroleum production rates reestablished.

Initially, the pores of the petroleum producing formation encompassed by the water block are usually substantially saturated with water, i. e., 75-100% occupied by water. It is preferred in the practice of this invention to reduce the water content of the pores of the formation encompassed by the water block to the irreducible minimum. Depending upon the geometric configuration of the pores or interstices of the formation the irreducible minimum water content is usually in the range 20-50% of the available pore space.

Various liquid petroleum fractions may be employed in the practice of this invention. Suitable liquid petroleum fractions include liquefied normally gaseous hydrocarbons such as liquid propane, butane and pentane or mixture thereof, i. e., liquefied petroleum gas (LPG), petroleum naphtha, such as hydrocarbons in the gasoline boiling range, kerosenes, diesel oils and light fuel oils. As indicated, it is preferred that the liquid petroleum fraction introduced into the water block has a viscosity

substantially the same as that of water when measured under formation conditions of temperature and pressure. Desirably there is added to this liquid petroleum fraction a surfactant material which reduces the surface tension of water to lower the interfacial tension between the water present in the water block and the liquid hydrocarbons thus-introduced into contact therewith.

Various gases may comprise the gaseous medium employed in the practice of this invention to dissipate the water block. Suitable gases include natural gas usually associated with or dissolved in the liquid petroleum within the petroleum producing formation and produced therefrom. Natural gas is usually comprised of a major amount of methane and minor amounts of ethane and propane. Another gas which may be employed in the practice of this invention is air. Still another gas which is suitable in the practice of this invention is a gaseous mixture of combustion products such as a flue gas and the like, usually containing nitrogen, carbon dioxide and other gases in varying amounts. If desired, it is possible in the practice of this invention to reduce the water content of the zone undergoing treatment to a value below the so-called irreducible minimum by injecting thereinto a hot gas, such as hot combustion gases, so as to dry the formation into which this hot gas is injected. In accordance with another aspect of this invention there is added to the injected gas a small amount of a vaporized material which deposits within the thus-treated formation a film which is preferentially wettable by oil, i. e., a hydrophobic film. Suitable materials for depositing such a film include the halo-silanes containing hydrocarbon groups such as the alkyl chloro-silanes including monomethyl dichloromonosilane, dimethyl dichloromonosilane, diethyl dichloromonosilane, dipropyl dichloromonosilane, dibutyl dichloromonosilane, triethyl monochloromonosilane and the like, which materials readily hydrolyze upon contact with water to form a hydrophobic film within the interstices of the formation. The thus-deposited hydrophobic, preferentially oil-wettable film further reduces the water permeability and increases the oil or hydrocarbon permeability of the formation into which these materials are introduced. Other suitable materials also are the aryl and the aralkyl halo-silanes.

Surfactant materials which may be employed to reduce the surface tension of water in the practice of this invention include any of the well known inorganic and/or organic surfactant materials, cationic, anionic and non-ionic agents. Suitable surfactant materials are readily available and include such materials as "Span" long chain fatty acid partial esters of hexitol anhydrides, including sorbitans, sorbides, mannitans and mannides sold by Atlas Powder Co., "Tween" polyoxyalkylene derivatives of hexitol anhydride partial long chain fatty acid esters, e. g., polyoxyalkylene derivatives of sorbitan monolaurate, sorbitan trioleate, sorbitan tristearate, sorbitan monopalmitate sold by Atlas Powder Co., "Aerosol" such as N-octadecyl disodium sulfosuccinamate, isopropyl naphthalene sodium sulfonate, diamyl sodium sulfosuccinate, dibutyl sodium sulfosuccinate, isopropyl naphthalene sodium sulfonate and dioctyl sodium sulfosuccinate sold by American Cyanamid Co. and "Freflo" sold by Dowell Inc. Other well known surfactant materials which reduce the surface tension of water are known and may be employed in the practice of this invention.

Referring now to the drawing which schematically illustrates a water block of the type which may be dispelled by employing the practice of this invention, there is indicated therein a well bore 11 which penetrates a petroleum or petroleum distillate producing formation 12. The well bore is lined with casing 14 which is provided with perforations 15 through which petroleum hydrocarbons are produced. The well bore 11 is bottomed in the lower portion of producing formation 12, casing 14 being packed off by means of packer 16. Immediately beneath and adjacent petroleum producing formation 12

may be a water-producing formation 18 which might give rise to the water which is simultaneously produced with the petroleum hydrocarbons from petroleum producing formation 12 by water coning, such as along water cone 19 the outline of which is indicated by dashed lines. Water might also be simultaneously produced together with the produced hydrocarbons via high permeability sections or stringers, such as stringer 20 which is indicated by dashed lines and which indicates the flow path of water from the water-producing formation 18 upwardly through petroleum producing formation 12 into well bore 11 via perforations 15. The extent of the water block or the zone surrounding well bore 11 within petroleum producing formation 12 affected or occupied by the water block is indicated by solid line 21. Within the zone encompassed by water block 21 the formation is substantially saturated with water and exhibits a low or drastically reduced permeability to hydrocarbons, particularly liquid hydrocarbons.

The water block 21 within petroleum producing formation 12 in accordance with the practice of this invention is dissipated or dispelled in the following manner. There is injected via casing 14 and perforations 15 into water block 21 a substantial volume, such as a volume at least equal to  $\frac{1}{4}$ – $\frac{1}{2}$  of the volume of the formation 12 encompassed by the water block 21, e. g., 100 barrels of a liquid petroleum fraction such as a naphtha distillate fraction or LPG. This liquid petroleum fraction is introduced so as to effect a more thorough displacement of the water from the interstices of the formation within the water block. After the introduction of the liquid petroleum fraction a gaseous medium such as natural gas is introduced into water block 21 via well bore 11 and perforations 15. For example, the natural gas injection may be at a rate of about 5,000 MCFD for about 2 days, the previously injected liquid petroleum fraction serving as a cushion between the subsequently introduced gaseous medium and the water occupying the interstices of the zone 21 of the formation 12 surrounding the well bore. Since the previously injected liquid petroleum fraction has a viscosity substantially the same as or approaching the viscosity of water the subsequently introduced gaseous medium better displaces the water from the water block.

After the gaseous medium has been injected for a sufficient length of time so as to substantially completely dispel the main body of water originally occupying water block 21 outwardly into petroleum producing formation 12 there is introduced via casing 14 and perforations 15 an additional amount of a liquid petroleum fraction containing admixed or dissolved therein a suitable surfactant material which reduces the surface tension of water. For example, there may be then introduced into the zone undergoing treatment about 5 barrels of a liquid petroleum fraction such as naphtha or kerosene containing about 50 lbs. of a suitable surfactant such as Aerosol. The surfactant material reduces the surface tension of water occupying the interstices of the formation encompassed within water block 21 and permits this water to be more readily displaced outwardly into the formation. As heretofore indicated, the initially introduced liquid petroleum fraction might also contain admixed therewith surfactant material so as to more readily displace the water from the water block 21 in the initial treating step. Following the second introduction of liquid petroleum fraction the injection of a gaseous medium, such as natural gas, is continued at substantially the same rate as before for an additional period of time, such as about 1 or 2 days so as to insure the substantially complete anticipation of the water block 21.

After the above-indicated treatment the production of petroleum hydrocarbons from petroleum producing formation 12 via perforations 15 and casing 14 is again resumed at a controlled rate approaching the previous production rates.

The practice of this invention is not only applicable to those wells which have been produced for a substantial

length of time and have eventually gone to water, that is, now produce substantially only water or which produce a minor amount of oil, less than 5% by volume, together with a major amount of water due to a water block with the producing formation, but is also applicable as a completion method for newly drilled wells wherein an aqueous drilling mud is employed while drilling through the petroleum producing formation from which the production of petroleum hydrocarbons is desired. In some instances when employing an aqueous drilling mud as a completion fluid a water block is formed within the petroleum producing formation. This water block must be removed from within the petroleum producing formation before the production of petroleum hydrocarbons can be commenced therefrom.

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

I claim:

1. A method of dispelling a water block from a zone surrounding a well bore penetrating a petroleum producing formation which comprises introducing via said well bore into the zone containing said water block a liquid petroleum distillate fraction in an amount substantially equal to the volume of said formation occupied by said water block, said liquid distillate fraction having a viscosity substantially equal to that of water under the formation conditions of temperature and pressure in said zone of injection, thereafter introducing via said well bore into the zone of injection of said liquid distillate fraction a gaseous medium to distribute the previously injected liquid petroleum distillate fraction within said formation and to dispel said water block outwardly from said zone into the formation, the volume of gaseous medi-

um thus-introduced being at least as great as the zone of said formation occupied by said water block, said volume of gaseous medium being measured under the formation conditions of temperature and pressure, subsequently introducing into the thus-treated zone via said well bore additional said liquid petroleum distillate fraction containing a surfactant material which reduces the surface tension of water and which reduces the interfacial tension between water and oil or other hydrocarbon liquids contained within the zone of the formation undergoing treatment, the volume of said additional liquid petroleum distillate fraction being in the range  $\frac{1}{20}$ – $\frac{1}{2}$  the volume of said liquid petroleum distillate fraction first introduced into the zone of said formation containing said water block, and thereafter injecting additional gaseous medium into the thus-treated zone via said well bore so as to substantially completely dispel said water block from said zone outwardly into said formation.

2. A method in accordance with claim 1 wherein said surfactant material is N-octodecyl disodium sulfosuccinate.

3. A method in accordance with claim 1 wherein said surfactant material is a long chain fatty acid partial ester of a hexitol anhydride.

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