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Application of Chemical Compounds in the Oil Recovery.

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ABSTRACT

This paper describes possibility of hydrogen superoxide application in the capacity of a chemical compound for the purpose to increase effectiveness of extraction of an irreducible oil by affecting on bound water. It is shown that in the course of hydrogen superoxide use in an oil pool reaction of interaction between oil-field water and injected water begins that is followed by the heat production resulting in thawing of a pool and breaking of molecules of bound water. In the method being discussed, the problem about interaction of 50 % hydrogen superoxide with bound water was solved using a field theory method and quantum statistics on the basis of modern bound water model. Within the range of temperatures higher than 343 K the phase disengagement of bound water, including its motionless component with extraction of a free water phase was observed. Possibility of structure breaking and removal of physically bound water by accessible chemical compounds is revealed.

Keywords: hydrogen superoxide, oil pool, irreducible oil, bound water, pool thawing

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INTRODUCTION

In the conditions of growth of a water cut in production and high depletion of reserves enhanced oil recovery methods become more and more important. The rig-up number grows every year that is directed to enhanced oil reservoir recovery which results in increase in volume of additionally produced oil. All methods of recovery of an irreducible oil after waterflooding can be applied here in the form of various updates [1], they are followed by complicated physical and chemical, gas dynamic, microbiological, and gravitational-seismic processes.

Many physical and chemical and hydrodynamic phenomena which take place upon injection of working substances in a pool, namely, in partially flooded petroleum deposits, are studied insufficiently. In this connection, key parameters of their application technology in particular geological and physical and operating conditions are selected only on the basis of qualitative models about nature of interaction of injected compositions of chemical compounds in a pool.

Caustic flooding was one of the first methods for physical and chemical stimulation of formation applied in fields of Western Siberia since 1976. All results gained during vast field experiment are worthy, however the tested modifications of flooding low-concentrated alkali solutions point on insignificant efficiency of the method. The first field experiment on injection of a concentrated alkali solution was held in 1985 in the Triozernoye field where into two injection wells there was injected a bank of 10 % alkali solutions with amount of 0.14 % from a void content of the lease [2]. In separate producing wells decrease of a water cut was noted in 4—5 months. So, the water cut at the beginning of the experiment has made 55—90 %, further it has decreased to 40—50 % and only by the end of 1990 the water cut has increased to 70—80 %. Such falloff of a water cut could be explained by alteration of a reservoir sweep by affecting over thickness due to clogging of water flushed zones of a pool and tapping in operation of interlayers which were not exposed to waterflooding earlier. Analogous results are gained on the Toluomsky field though its pool characteristics were much worse: large average number of permeable intervals, lower permeability and productivity. The bulk of injected bank has made 0.3 % from a pool void content, at the experiment beginning the lease was water-flooded up to 40—50 %, after an injection of alcali solution the water cut was decreased to 20 30 %. The incremental oil production has made 35.8 thousand t or 42.4 t per ton of the consumed compound. The gained positive results of field experiment testify that this production engineering is effective for medium and low-permeability formations with small (up to 10 m) thickness. Field tests of the stimulation method for the sites represented by significant thickness of a formation equal to 15 m and more, such as the North Martyminsky reservoir and Martymya-Teterevsky reservoir, have demonstrated low efficiency of its application.

Application of 1 % alcali solution in four fields of the Perm region (Shagirtsko-Gozhansky, Padunsky, Opalikinsky and Berezovsky) have demonstrated [3] that 1 % alcali solution increases hydrophilic properties of terrigenous rocks and does not change wettability of chalk stones, and the discharge rate of alkali and amount of a sediment are increased upon water salinity and alkali concentration raise. In the case of water salinity of 265 g/l the sediment maximum amount of 19 g/l is formed, the alkali discharge rate makes 2.5 mg/g of rock, and the sequential injection of muds increases displacement efficiency by 2.5—4 %.

The technology for control of water conductive channels permeability in a pool by silicate and alkaline solutions was implemented in several modifications, the basic modification engages an injection of separation banks with soft water and a solution (a mixture of sodium hydroxide, liquid glass, and polyacrylamide). An injection of banks was retried periodically in 1—3 years, mainly, within 10—15 years. Banks of petroleum displacement agents are injected in the following order: the waste mineralized water which is injected for an oil displacement; a separation bank of soft water; and then a bank with sodium hydroxide solution. However, the discussed technology is directed only on regulation of in-place permeability and cannot effectively lock up flooded pool zones selectively that is possible only in case of an injection of great bank volumes.

The technology has found wide application that is based on injection of water solutions of various polymers in the capacity of thickened water in a pool, for example, use of polyacrylamide which molecular weight is more than 500 000, and viscosity of its water solutions is directly proportional to molecular weight. Depending on polymer properties water viscosity can be increased in a few tens times at admissible concentrations. When injecting polyacrylamide solutions in a pool [4] the conformance factor of reservoir by stimulation is increased due to equalization of oil and spacer fluid viscosities, simultaneously there is some decrease of a mean injectivity of fill-in wells due to increase in injected water viscosity. Besides, injection capacity is affected by decrease of a phase permeability for water because of interaction and adsorption of molecules of polymer on a rock surface.

Analysis results for efficiency of a usual polymer waterflooding demonstrate that the range of application of the last as well as other methods for enhanced oil reservoir recovery are limited to a water cut of produced fluid which is equal to 60—70 % and caused, as a rule, by formation of the flushed high-permeability zones in a producing reservoir. In these conditions filtration resistance of a porous medium upon its treatment by polymer is practically not changed. More effective application of a polymer waterflooding on earlier development stage of oil-fields is explained by that phenomena. It is necessary to note that along with an increase of a pool temperature higher than 70 ° C there is a breakage of polymer molecules and decrease in efficiency of its application for enhanced oil reservoir recovery. In the case if a permeability coefficient of a pool is less than 0.1 μm^2 polymer waterflooding process is difficultly implemented, as dimensions of molecules in the solution are larger than pore sizes and there is either its clogging in a bottom-hole zone, or a desintegration of polymer molecules.

A successful enough solution of the problem on limitation of move of oil-field waters in the flushed interlayers of a non-uniform pool is the method of injection of polydisperse systems into flooded interlayers. The main componennts of this system are ionogenic polymers with flocculating properties and clay dispersion particles. By selection of polymer and clay concentration in a clay suspension conditions for full binding of polymer (flocculation) therefore there are formed clay-polymeric complexes with new physical properties that are resistant to flow washing-out. Optimum concentration of a polymeric solution for the terrigenous rocks providing creation of a polydisperse system makes 0.05—0.08 % by weight. As a result of polydisperse system formation in a high-permeability flooded interlayer there is an essential immobilization of the fluid, injected water is forced to move through less permeable seams more effectively displacing an irreducible oil.

Experiments have shown [5] that mobility of water after treatment by a polymer-disperse system is decreased in 2—4 times in comparison with an injection only of a polymer solution or clay suspension, the residual resistance factor is increased with raising of a permeability coefficient of a rock. In the conditions of the increased saltiness of oil-field waters and content of calcium and magnesium salts water solutions of the most accessible polymers become unstable, their structure is broken and the effect of water thickening water disappears, while the most resistant biogenic polymers are practically inaccessible.

Necessary polymers are difficult-to-obtain and expensive products. Therefore, from the point of view of decreasing expenditures on enhanced oil recovery [6] the methods based on use of lower-cost and not scarce chemicals are of special concern.

The results analysis for studies of enhanced oil recovery methods application efficiency with application of surface active agents, polymers, trisodium phosphate, concentrated sulfuric acid in rather equal conditions of various fields demonstrates that the highest results are reached upon use of chemical compounds which along with improvement of oil displacement due to sweeping oil provide increasing of a pool sweep by stimulation.

HYDROGEN SUPEROXIDE APPLICATION

A prospective way to increase in efficiency of irreducible oil extraction is affecting on bound water. In the course of an oilfield development which involves banking, injection through a fill-in well through an oilwell tubing of a solution and its disintegrating inside a pool with heat production and the subsequent injection of water and oil lifting through production wells, 50% hydrogen superoxide was injected into a fill-in well in the capacity of a solution in volume equal to 0.3 of void volume [7]. Hydrogen superoxide was injected between two banks using a fluid neutral to hydrogen superoxide. Volume of the fluid neutral to hydrogen superoxide was accepted equal to 1.1 from oilwell tubing volume.

Hydrogen superoxide is a weak diatomic acid and its dissociation proceeds in two stages, however mainly it dissociates at a first stage with formation of following ions to very insignificant extent:

$$H_2O_2 \leftrightarrow +H^+HO_2^-.$$

Dissociation at a second stage practically does not occur, as it is depressed with presence of water, which is the matter dissociating with formation of hydrogen ions to more extent than hydrogen superoxide.

However, when introducing a catalyst agent in a hydrogen superoxide solution, it becomes possible due to reaction equilibrium offset to provide possibility of dissociation according to a second stage, too, with formation of highly reactive anion of oxygen:

$$HO_2^- \leftrightarrow +,H^+O_2^{2-}$$

Capable in the presence of a highly reactive oxidant to exhibit the reducing properties:

$$O_2^{2-} - \rightarrow 4_e^- O_2^0.$$

Acetat buffer was used in the capacity of a fluid neutral to hydrogen superoxide and for keeping up constancy of medium *pH*:

$$CH_3COOK + H^+ \leftrightarrow + CH_3COOHK^+$$

$$CH_3COOH + OH^- \leftrightarrow + H_2OCH_3COO^-$$

Potassium hydroxide in volume of 0.1 from hydrogen superoxide volume was used in the capacity of the catalyst agent. Further, 5 % solution of sodium permanganate was injected after two banks, and then oil was displaced to production wells by means of water. Introducing into the system of the potassium hypermanganate being a strong oxidant, originates process of hydrogen superoxide disintegration creating reduction-oxidation pair with a manganese ion (II). Owing to hydrogen superoxide disintegrating in the course of active involvement of potassium hydroxide and potassium hypermanganate, gas oxygen, ions of manganese (II), potassium and acetate will be present in the pool. As a result of a redox process with involvement of hydrogen superoxide, potassium hypermanganate and potassium hydroxide there is an active process of formation of free molecular oxygen and emission of a considerable quantity of heat which is expressed by the following equation:

$$2H_2O_{2(ж)} \leftrightarrow + 2H_2O_{2(ж)} + O_{2(г)} 197.5\ \text{kJ}.$$

After realization of the described operations in an oil pool reaction of interaction of oil-field water and injected water with hydrogen superoxide begins which is followed by heat production resulting in thawing of the pool and breaking of molecules of bound water.

It is known, that one of the major reasons of low oil recovery are particular hydrophobic interactions on a surface of rock in the presence of water. Interaction of oil with porous mediums is hydrophobic, and change of hydrophobic interactions controls activity of an oil displacement. The bound water adsorbed by a surface of rock is close to a solid body by its structure (condensation and crystallization structures). For a number of pool models after their stimulation by compounds occurrence of a new phase of bound water is noted that decreases an oil recovery. A significant part of the compound is irreversibly absorbed by movable component of bound water changing its physical and mechanical properties.

In the method being discussed, the problem about interaction of 50 % hydrogen superoxide with bound water was solved using a field theory method and quantum statistics on the basis of modern bound water model. Within the range of temperatures higher than 343 K the phase disengagement of bound water, including its motionless component with extraction of a free water phase was observed, i.e. structure breaking and removal of physically bound water was occurred.

INSIGHTS

It is necessary to note that the presented procedure and the method on application of a solution injection containing hydrogen superoxide is one of technological alternatives which optimum mode can be revealed after conducting of necessary amount of field tests.

CONCLUSION

Thus, it is offered in the capacity of lower-cost and abundant chemicals to use hydrogen superoxide with its feeding into an oil pool that will allow directly deep in the oil pool to carry out its effective stimulation due to exothermic disintegrating of hydrogen superoxide.

COMPETITIVE INTERESTS

The author affirms that the introduced data do not contain the competitive interests.

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