Patented Feb. 8, 1944

2,341,500

UNITED STATES PATENT OFFICE

2,341,500

PROCESS OF RECOVERING OIL FROM OIL SANDS

Kenneth D. Detling, Berkeley, Calif., assignor to Shell Development Company, San Francisco, Calif., a corporation of Delaware

No Drawing. Application January 10, 1942, Serial No. 426,282

4 Claims. (Cl. 166—21)

The present invention relates to the rcovery of oil from depleted oil sands and pertains more particularly to methods of flooding such sands with water to obtain a secondary recovery of oil.

In oil fields where the oil production from wells by pumping has ceased or become unprofitable, it is the practice to recover some of the residual oil, which sometimes amounts to sixty per cent of the original oil present, by means of a water flood. Water is introduced under pressure into a number of wells, and oil together with water is produced from other wells by the resultant water drive. Heretofore, many agents, such as surface tension reducing and capillary active agents, have been proposed as addition agents to the flooding water to increase the efficiency of the water flood. However, due to various reasons and/or circumstances, these methods of secondary recovery have not been altogether satisfactory.

Incomplete cleanup of the residual oil from the oil sands has been due at least in part to the fact that the variations in the permeabilities of the oil-bearing strata cause the outer portion or leading front of the water flood to finger or to progress through one stratum ahead of the water in an adjacent stratum. In other words, the boundary between the flooding water and the driven liquid ahead of it becomes indistinct or non-uniform, whereby the advancing front of water bypasses some oil-bearing sands, irrevocably trapping the oil therein. This fingering of the flood front may be due to fractures and large flow channels in highly permeable zones. The trapping of oil in pockets occurs particularly in oil sands which are non-uniform in texture and/or are formed of thin strata of different permeabilities. In some such non-uniform sands, secondary recovery by water flooding cannot be economically applied.

Some addition agents are objectionable, apparently for the reason that they build up deposits on the strata tending to plug or seal off the less permeable strata, and perhaps in some ways produce results which are inferior to those which are obtainable by the use of water alone.

It is therefore an object of the present invention to provide a flooding method wherein the flood front forms a substantially distinct barrier and progresses more uniformly through the oil sand, whereby fingering of the flooding liquid and trapping of oil are lessened and the less uniform oil-bearing formations can be successfully water-flooded.

Briefly, this object and others, as will be apparent from the following description, may be accomplished by adjusting the viscosity of the forward portion of the flooding liquid so that the ratio of the viscosity of the flooding liquid to the oil to be recovered or displaced is increased. More particularly, the present method comprises the steps of first injecting into the depleted oil-bearing strata prior to the introductoin of the flooding water a substantial volume of a viscous liquid having a viscosity substantially greater than water and preferably having a viscosity of the order of or greater than that of the oil to be recovered, and then introducing ordinary flooding water, whereby the flooding front forms a substantially distinct and symmetrical barrier progressing through the oil-bearing strata, substantially unaffected by variations in the texture, permeability, porosity, or capillarity of the strata. The nature of such viscous liquids substantially prevents fingering of the flooding front since the relatively high viscosity of the flooding front liquid causes it to flow more slowly through the large channels in the highly permeable zones, thereby more nearly equalizing the progression of the flooding liquid through various zones of different effective permeability. Under these conditions, the flooding rate can be adjusted to values at which more complete stripping of the oil from the sand occurs.

Viscous liquids which may be used include both aqueous and non-aqueous liquids and solutions having viscosities substantially above that of water and preferably of the order of that of the oil to be recovered from the depleted oil sand. Liquids having viscosities ranging from 0.8 to 16 centipoises or more, or less, and preferably from 3.0 to 6.0 centipoises, may be used, depending upon the viscosity of the oil to be displaced, the nature of the formation, the temperature, etc. The viscous solutions may preferably have detergent properties which enhance the cleanup of the more or less adsorbed or "fixed" oil, and for this purpose small amounts of wetting or surface-active agents may be added to or incorporated in the viscous liquid; however, the essential feature of the present invention resides in the use of a viscous liquid as a fluid piston ahead of the flooding water. When adding wetting agents, the cation-active type, such as the onium, e. g. alkyl pyridinium, salts, etc., are preferred since these agents are unaffected by calcium and magnesium ions which are usually present in the formation water and in natural brines.

Suitable viscous liquids which may be used for the present purpose include aqueous solutions of certain soaps, such as sodium oleate in admix-

ture with phenol and the like; hard water soaps, such as sodium lauryl sulfate; alkali metal salts of alginic acid, such as sodium alginate; glycerine; sucrose (or crude sugars) with or without additions of phenol and the like; water-soluble polymers, such as polyvinyl and poly-allyl alcohols; and non-aqueous solutions of various thickening materials, such as hydrocarbon polymers; for example, poly-isobutylene, nitrocellulose, cellulose nitrate, ruber in benzene, etc.; and various admixtures thereof as well as such liquids containing wetting agents, preferably of the cation-active type, such as the quaternary ammonium compounds which have a long hydrocarbon chain, for example, Sapamine, etc. It is preferable to use solutions from which precipitates are not formed on admixture with naturally occurring salts. For this purpose, water-soluble hexametaphosphates and the like may be added to the solutions as suppressors of precipitate-forming ions.

As examples of specific viscous liquids which may be used according to the present invention, the following are given:

An aqueous solution consisting of 4.25% sodium oleate, 0.75% phenol, and 95% water is suitable and has a viscosity of 3.62 centipoises. Other mixtures of sodium oleate and phenol have compositions of 9% and 1%, 8% and 2%, 6% and 2%, and 8.5% and 1.5% of sodium oleate and phenol, respectively, the remainder being water. These solutions are particularly effective since their detergent properties cause a more complete cleanup of the oil.

A 40% sucrose solution in water has a viscosity of 4.5 centipoises at 30° C. and may be used. Other suitable solutions of 30% and 40% sucrose with 1% phenol and 0.5% m-cresol, the remainder being water, have viscosities at 30° C. of 3.1 and 4.8 centipoises, respectively.

In carrying out the method of the present invention, the injection wells and producing wells are prepared in the usual manner. A viscous liquid is first introduced into the depleted oil sands through the injection wells for a period of 12 to 48 hours or more, depending on the distance between the injection wells and the producing wells and their spacing, in order to insure that the viscous liquid is maintained at a sufficient thickness as the diameter of the flooding front increases. Then the flooding water is introduced, directly following the viscous liquid. This may be accomplished in various ways; for example, the supply of viscous liquid to the injection well downpipes may be shut off slowly as the supply of water to complement the viscous liquid is started.

While it is preferable to flood out oil sands with a flooding liquid having a viscous flood front, infrequent injections of viscous liquids during the flooding period may be desirable to even out the flood pattern or to re-establish a more uniform rate of injection of flooding liquid into the various formation zones and to prevent by-passing in the watered-out region of the depleted oil sands.

Any suitable system for injection the flooding water may be used. It is preferred, however, to use a closed water system, such as according to U. S. Patent 2,230,001.

The relatively high viscosity of the viscous flooding front minimizes or neutralizes the fingering effect or by-passing of portions of the flooding liquid by decreasing the speed of flow of flooding liquid through the larger channels and the more permeable zones, whereby the range of effective permeabilities values is narrowed so that a more uniformly progressing flooding front or band is obtained and thus permitting a greater percentage recovery of the oil remaining in the depleted oil sands than heretofore has been possible.

I claim as my invention:

1. A flooding process for recovering oil from depleted oil sands comprising the steps of first injecting into an input well a viscous liquid consisting of an aqueous solution of sodium oleate and phenol, then injecting water into said input well and forcing said liquids through the depleted oil sand towards an outlet well.

2. A flooding process for recovering oil from depleted oil sands comprising the steps of first injecting into an input well a viscous liquid consisting of 4–9% sodium oleate, 2–0.5% phenol, and the remainder water, then injecting water into said input well and forcing said liquids through the depleted oil sand towards an outlet well.

3. A flooding process for recovering oil from depleted oil sands comprising the steps of first injecting into an input well a viscous liquid comprising an aqueous solution of a fatty acid soap and a hydroxy-aromatic compound, then injecting water into said input well and forcing said liquids through the depleted oil sands towards an outlet well.

4. A flooding process for recovering oil from depleted oil sands comprising the steps of first injecting into an input well a viscous liquid comprising an aqueous solution of an alkali metal soap of a higher fatty acid and a hydroxyaromatic compound, then injecting water into said input well and forcing said liquids through the depleted oil sands towards an outlet well.

KENNETH D. DETLING.