A REPORT OF PROGRESS OF THE RESULTS OF FLUSHING OIL SANDS WITH ALKALINE SOLUTIONS

W. E. GORDON and O. T. LUND
University of Tulsa

The experiments of the flushing of oil sands with alkaline solutions were started about two years ago by Prof. R. C. Beckstrom and Dr. F. M. Van Tuyl at the Colorado School of Mines. The solution employed by these investigators were as follows: ordinary tap water, solutions of neutral salts, solutions of acid salts, strong acids, weak acids, concentrated alkaline solutions, dilute solutions of the hydroxides of the alkalies, and dilute solutions of the salts of weak acids and strong bases. Of this long list of solutions those of the salts of weak acids and strong bases were the most effective. Since a limited amount of exact data on the per cent recovery, cost of recovery, and relative effectiveness of the solutions of these different salts is available at the present time, experiments to obtain such information have been started.

The investigation being conducted at the present time was started by Prof. R. C. Beckstrom, and in his absence, is being continued by W. E. Gordon and O. T. Lund, under the direction of Drs. F. T. Gardner and A. N. Murray.

Beckstrom and Van Tuyl found that the use of dilute solutions of the salts of weak acids and strong alkali metals were the most effective in the recovery of oil from sandstone by the flushing method. Since the use of this group of salts shows a greater efficiency in the recovery of oil than other groups, only members of this group are being used in the present investigation.

This paper is a report of progress on a series of experiments which are being conducted at the School of Petroleum Engineering, University of Tulsa, relating to the flooding of oil sands with alkaline solutions. Only a small amount of the data is available at the present time as compared with that which will be available at the conclusion of the experiments. The object of this investigation is to determine as far as possible the following data.

1. The concentration of flushing solutions required to produce the most satisfactory recovery of oil.
2. The relative efficiency of different solutions in recovering oil from oil sands.
3. The effect of variations in temperature of the flooding solutions on recovery of oil.
4. The effect of variations in texture and porosity of the sands on recovery of oil.
5. The influence of alkaline solutions on the cementing material of sandstones.
6. The effect on the concentration of alkaline solutions on being used in the flooding process.
7. The effect of alkaline flooding solutions upon oil.

A block of Pennsylvania sandstone varying between 2000 and 4500 cc.

Experimental Methods and Procedures

in volume is drilled to one-half the depth of the block. An iron pipe one-fourth inch in diameter is firmly cemented into the sandstone with "Smooth-On" iron cement. The sandstone block is then submerged in Morris-Boynton, Oklahoma, district crude oil and vacuum applied through the pipe until the rock is saturated with oil. The time required for saturation depends upon the size of the sample, the porosity of the rock, the viscosity and the gravity of the crude oil being used. After the block is completely saturated, it is placed in a glass jar filled with water, which is provided with an overflow pipe near the top. The overflow from the jar is measured accurately thus giving the definite volume of the rock being tested. The remainder of the water in the jar serves to float the recovered oil into separatory funnels. The solutions are introduced into the sandstone blocks through the above mentioned pipes at a pressure ranging between 20 and 25 pounds which pressure is maintained throughout the experiment.

The amount of oil and the continuous porosity of each sandstone block was obtained by weighing the rock dry and after saturation with oil. The percent recovery was calculated with respect to the amount of oil used in saturating the rock.

The solutions which have been used to date are those of sodium oleate, borax, and tri-sodium phosphate. The temperature of the solutions used was always that of room temperature which varied between 18° and 20° C., somewhat lower than that which is found at the bottom of the average well. The data which has been obtained are as follows:

1. Solution used—Sodium Oleate

Concentration of solution	½ per cent
Amount of solution used	800 cc.
Volume of sandstone block	2500 cc.
Weight of block dry	4811 gms.
Weight of block saturated with oil	5408 gms.
Weight of oil absorbed	596.2 gms.
Porosity of sandstone	19%
Gravity of crude oil	35° Baume
Amount of recovered oil	320 gms.
Gravity of recovered oil	34° Baume
Percent of Recovery	53%
Time of Recovery	27 hrs. 45 min.

2. Solution used—Borax

Results Obtained by Flushing Oil Sands

Solution used	Sodium oleate	Borax	Tri-sodium Phosphate
Concentration of solution (%)	0.5	2	2
Amount of solution used (cc.)	800	1,200	1,200
Volume of sandstone block (cc.)	2,500	2,740	4,740
Weight of block dry (gms.)	4,811	5,302.7	8,924.2
Weight of block saturated (gms.)	5,408	5,849.0	10,103
Weight of oil absorbed (gms.)	596.2	546.3	1,178.8
Porosity of sandstone (%)	19	16	13
Gravity of crude oil (°B′)	35	35	35
Amount of recovered oil (gms.)	320	290	638.2
Gravity of recovered oil (°B′)	34	33.8	34
Per cent recovery	53	53	54
Time of recovery (Hrs., Min.)	27-45	20	15

In comparing these data, it is found that a range of porosity between 13 and 19 per cent has little or no effect on the percent recovery, as the sandstone with a porosity of 13 per cent gives a 54 per cent recovery, while one with 19 per cent porosity gives 53 per cent. The ratio by weight of the solution used to the oil recovered is 3 of oil to 8 of solution in the use of sodium oleate, 2 to 8 in the use of borax and 4 to 8 in the use of tri-sodium phosphate showing the superiority of tri-sodium phosphate. Assuming the time necessary to perfect recovery with sodium oleate as unity, the time necessary for recovery with borax is⅘ and that with tri-sodium phosphate ⅔.

From the above comparison of the data available at the present time, tri-sodium phosphate seems to be the most desirable salt for use in flushing provided that there are no salts in the oil field waters which will form insoluable compounds on reaction with the salt used in the flushing solution.