Surfactant Treatment Of Injection Wells

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Getting more water into or oil out of a reservoir at lower pump pressures has been an undertaking at which the waterflood operator has worked since the beginning of secondary recovery. Chemical attempts to solve this task have at least a 40 yr history: a patent was issued to a Mr. E. Flyeman in 1920 and covered the use of dilute sodium carbonate in tar sands to strip crude hydrocarbons. Shortly thereafter a Mr. P. G. Nutting described the use of sodium carbonate in flood waters in ciliceous reservoirs.[1]

Organic surfactant materials have experienced at least 13 yr of trial. As early as 1950 there were recorded efforts to reduce residual oil saturation through the use of various cationic and nonionic materials.

During the past several years, a program has been in progress with Armour to attempt to determine the most common injection troubles -- experienced by the operator -- that would lend themselves to chemical solution, and to find the particular chemical or combination which would appear best for each condition.

Five problems were designated as potential areas of interest for which surface active chemicals may offer solutions:

1. Wettability characteristics tending toward oil-wet
2. Low permeability of sand to be flooded
3. Oil-iron sulfide accumulations on the sand face
4. Kaolinite clay particles which may plug capillaries
5. Hydratable clays such as bentonite

The second step, quite naturally, was the attempt to solve the problems. The U. S. Bureau of Mines capillarimeter was used in determining which materials would tend to shift wettability characteristics toward the water-wet side. Interfacial tension information was used to choose materials potentially best suited for aiding injection into tight sands. Visual determination of separation of oil and iron sulfide was made on several collected samples to choose the optimum chemical for this task. Filterability of treated water through clays was used to determine the material which could best be used where this was the problem. Admittedly, there will be few occasions where the problems in a well can be so ideally isolated.

The materials so chosen are classed as "detergents" which, by definition, will

1. lower the surface tension of the water
2. disperse solids in water
3. form foam
4. tend to water-wet any solids present
5. emulsify

Since "emulsify" in the petroleum industry is normally a dirty word, some explanation of the term becomes necessary. Emulsification will aid in removal of oil, paraffin, and treating chemicals from the sand.

Throughout the United States and for periods of 18 to 40 months field trials of several chemicals have been conducted with an encouraging percentage of successes reported to date.

One of the first controlled field trials of these chemicals took place in one of the Bradford sands in northern Pennsylvania. Because of the multiplicity of problems in this field -- namely a very tight sand of 0.5 millidarcy permeability, an oil-wet sand, and sulfate reducing bacterial contamination -- a chemical was chosen which, it was felt, would give optimum benefits on all counts. Treatment consisted of filling the well with gasoline, shutting the well in for 24 hr, then backflowing the solvent out of the well. Water containing 60 ppm of a cationic surfactant was injected for 24 hr, after which a continuous 10 ppm concentration was attained. Injection rate after treatment was about 5 times that before treatment, and has held at this level for about 3-1/2 yr.

Low permeability was said to be responsible for low injectivity of 2 Pecos County, Texas wells taking about 120 PBD and 150 BPD of water at maximum pressures for the pumping equipment at location. Initial treatment was 1 quart per day per well of a non-ionic material for 30 days. During this period, injection rates increased to 190 and 250 BWPD respectively. Treatment frequency has since been reduced to 3 times per week with no further decline in injection rates.

Tight, shaly, kaolinite-containing sands have been successfully treated in a Permian sand in the same West Texas area mentioned above. A well in this fresh waterflood was taking 13 BWPD at 660 psi pump pressure. Previous attempts to acidize gave at best extremely temporary results. A mixture of 100 ppm of a slightly cationic material in 15% HCl was made and the well acidized. For 7 days following acidization, the water to be injected was also treated with 100 ppm of the same agent. Concentration the second week was reduced to 50 ppm after which continuous treatment at 20 ppm was made. Immediately after acidizing, the well took 49 bbl water at 535 psi, and, after 13 months, the well was taking 70 BWPD at 540-660 psi.

Separation of oil and iron sulfide has been accomplished effectively with surfactants. One material has worked extremely well when added to HCl and has allowed the acid to strike through the oil and work on the iron sulfide. The successful use of another material in a Southern Illinois salt water disposal system was recently disclosed. The Devonian water to be injected was unfiltered and contained high concentrations of H_2S, FeS, and oil. Before the chemical was used, acidizing was attempted about every 10 weeks, immediately following which the well would take about 5500 BWPD at a capacity 300 psi pump pressure. A rather rapid drop-off in injection rate would then be experienced for about a week followed by a slower decline in rate and an increase in pressure to about 3500 psi, at which time the operator would again acidize. Daily treatment of chemical was begun at a concentration of about 8 ppm. A gradual increase in injection rate was accompanied by a pressure decline to a point where the well is now taking all water available, about 6200 BPD, and the pumps operating intermittently at no more than 250 psi. The operator feels that the well would take 8 to 10,000 BPD with their present equipment.

Several factors remain unexplainable in using these several injection well stimulators. For example, offset injection wells, supposedly completed identically, have responded differently when subjected to the same treatment. In a West Texas Greyburg flood, a surfactant was chosen to treat by "slugging" 2 offset wells. Injectivity of 1 well was increased by 200% while the other did not respond. Because logs or cores were not available it was not possible to compare sands, although both wells were reported to contain about the same footage of gross pay.

Millipore filter runs have been made on several systems to determine applicability to the choice of chemical to be recommended. It is felt that the information obtained from this tool will be helpful when coupled with knowledge of bottom hole conditions and type of formation to be encountered.

Introducing the surfactant into the reservoir has been accomplished by several methods. From an overall economic standpoint considerable success has been derived from a "slug" treatment, consisting of introducing the prescribed daily requirement directly into the injection well through a lubricator, gate valve, or whatever is convenient.

A somewhat more desirable method would be addition of the chemical to the water in a surge tank where some dilution can occur and thus afford a longer period of time to put the chemical away and enhance the opportunity for the material to perform its required task.

A third method would make use of a chemical proportioning pump and would give the advantage of direct injection coupled with the long term effect enjoyed by adding to a surge tank.

Probably the most important factor to stress in giving a surfactant the best chance of success is cleanliness of the sand face. A well should be cleaned with a surfactant-acid combination or solvent wherever possible. Because of the large surface area which may be present with wellbore contaminants, there could be a decrease of surfactant availability. The nonionic and slightly cationic chemicals chosen as stimulants reduce this tendency, but it does still exist. Therefore, the adage of cleanliness being next to Godliness may well be applied to injection well stimulants.

The program as originally described is by no means complete. Records are being compiled on all treatments in an attempt to further enlighten us on the mechanism involved, and on the question of why a specific chemical will perform considerably better on one well than on another. Geologic and geographic locations, type of formation, water analysis, and possible bottom-hole contaminants all are being considered. It is hoped that the study will enable a somewhat more scientific approach be made to selection of materials in the future.

REFERENCES

1) L. C. Uren. Petroleum Production Engineering, Exploitation, 3d ed.
2) H. N. Dunning and R. T. Johansen. "Measurement of Crude Oil Wetting Tendencies," Petroleum Engineer, (July, 1958).