THE USE OF AN INTERFACE TO CONTROL STIMULATION AND CEMENTING TREATMENTS

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As the energy situation becomes more critical and more domestic oil is desired, new methods of stimulation are needed. Conventional methods generally have not been successful in treating thick or massive pay sections whether in cased or open hole. This has been true for squeeze cementing as well as fracturing and acidizing treatments.

In the Levelland-Sundown areas of West Texas, most of the producing formations are thick, fractured limestones of varying porosity and permeability. The problem here has been to treat the low-permeability or tight zones as well as the more permeable zones. Many diversion methods have been tried without success. These have included straddle packers, ball sealers, and the suspended-solids type of blocking agents. While all of these may force the stimulation fluid to enter the tight zone, the fluid generally will penetrate only a short distance before seeking a fracture back into the more permeable zones. As a result, fluids from later stimulation treatments have undoubtedly been injected back into the originally treated zone time after time. The same is probably true of cement when attempting to squeeze-off undesired zones such as water-producing zones or channeled zones in injection wells.

A new method of diversion has been employed with a high degree of success in this area during the last two years. The method involves the use of two fluids, one "tagged" with a radioactive material and another "untagged" fluid. The "tagged" fluid normally is pumped down the annulus while the untagged fluid is pumped simultaneously down the tubing. A detection tool, run on a wire line, is used to monitor the interface between the two fluids.

The interface indicates the place of entry of the two fluids into a zone. The location of the interface is controlled by means of pump rate. It can be moved up or down by varying the pump rate down the tubing or annulus or both.

The interface method allows control of stimulation fluids not only at the wellbore but out in the formation as well.

Figure 1 illustrates one type of interface treatment. In this example, the problem is to acidize a low-permeability zone below a zone of higher permeability. In this case radioactive water is pumped down the annulus while acid is pumped simultaneously down the tubing. The radioactivity detector is located in the tubing and the interface is controlled at the top of the low-permeability zone. Most acid inhibitors are capable of protecting the wire line and detection tool from damage by the acid. However, in extremely deep or hot wells, special inhibition requirements may be required by the wireline company.

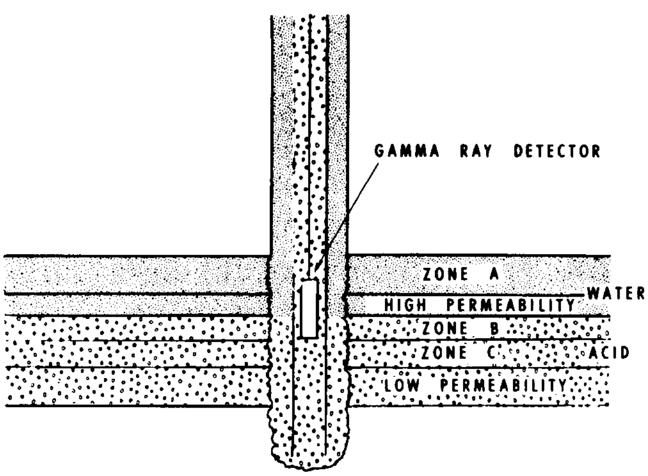

FIG. 1—INTERFACE TREATMENT OF LOW PERMEABILITY ZONE BELOW ZONE OF HIGHER PERMEABILITY

In Fig. 2, the problem is exactly the opposite of that in Fig. 1 and is the problem usually encountered in the Levelland-Sundown area. Here the zone has 'the highest permeability and contains water. In conventional treatments the majority of the treating fluid tends to enter this zone. In this case, the acid is radioactively tagged and pumped down the annulus. The water is untagged and is pumped down the tubing into the water, or high-permeability, zone. The detection tool is again run in the tubing and the interface controlled at the lower boundary of the low-permeability zone. Water must be pumped into the bottom zone until a stable injection rate and pressure are established. This may require 500-1000 bbl of water in this area, but a stable interface is required before the treatment can start.

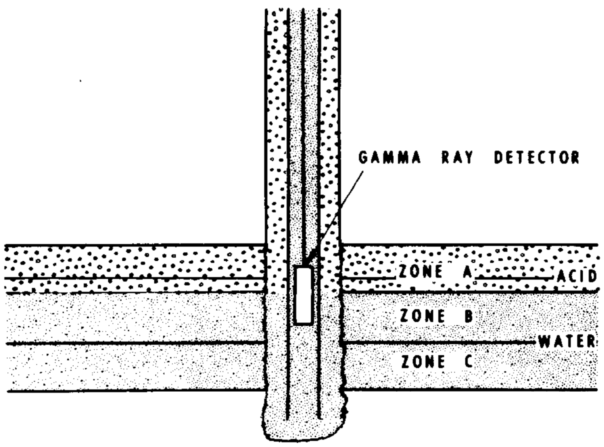

FIG. 2—INTERFACE TREATMENT OF LOW PERMEABILITY ZONE ABOVE ZONE OF HIGHER PERMEABILITY

One problem that occurs in this area in interface method stimulation treatments is that one zone or the other may begin accepting too much fluid. This can be controlled partially by use of blocking agents such as rock salt, benzoic acid flakes or graded moth balls. Both the flakes and moth balls are oil-soluble and water-insoluble. They are generally preferred since most of the stimulation treatments use fresh water.

CEMENTING

The latest use of the interface technique has been in squeeze cementing operations designed to shut off water-producing zones. Conventional squeeze jobs as well as water-swellable polymers have proved unreliable since there has been no method to control placement of the materials.

In the Levelland area, many wells produce large volumes of water. The water hinders oil production and a water shut-off is desirable.

In the past, squeeze cementing has been done through tubing and packer with the cement allowed to enter the zone of least resistance. In many cases the cement has entered the wrong zone and oil production has been reduced.

The interface method improves the chance of placing the cement in the desired zone. In squeeze operations the interface is established in the same manner as in a stimulation treatment. Enough horsepower is required on the annulus to help hold the squeeze as long as possible without losing the interface. Since pressure increases on the annulus as the squeeze is obtained, it becomes difficult to maintain the interface.

In the Levelland area, the objective of a squeeze job is normally to fill either natural or hydraulically created fractures. Neat cement is not recommended. The most successful cement systems have contained large amounts of fluid-loss additives and small amounts of calcium chloride. (Calcium chloride is required because the fluid-loss additives have a retarding effect on the cement slurry.)

The interface technique has also been used to squeeze injection wells in this area. The objective here is to correct injection profiles. In most cases the injected water enters the lower zone which contains water. In these wells, the interface is established by pumping radioactive fluid down the annulus and water down the tubing. The cement is then pumped down the tubing for the squeeze. It has no trouble passing by the gamma ray detection tool which remains in the tubing during the job. If the interface is maintained at the boundary between the upper and lower zone, cement is prevented from entering the upper, or oil-producing, zone.

CASE HISTORIES

A San Andres well was producing 350 BWPD and 20 BOPD. The bottom water was reducing the flow of oil to the well bore. The interface was established with the tubing near the bottom. Tubing had a spotting valve attached to aid in keeping hydrostatic head off the column of cement. A wireline radioactive detection tool was run in the tubing. The radioactive fluid was pumped down the annulus to monitor the interface. The injection rate on the annulus was 1.4 BPM and cement was pumped down the tubing at

0.25 BPM. The well took 75 sacks of cement before the pressure on the annulus became too great (950 psi). The job was halted to prevent fracturing the upper zone with the radioactive fluid. The tubing contained 10 sacks of cement or 2.5 bbl of slurry. The pressure on the tubing at this point was 3990 psi. This was due to the spotting valve being set at 3700 psi. The tubing was pulled wet immediately and the well was shut-in 24 hours. Production 90 days after the job was 20 BOPD and 30 BWPD. Although oil production did not increase, water production was significantly reduced.

Case history 2 involved a situation that was nearly the same as above except for the results. Before squeeze, the well was making 60 BOPD and 370 BWPD. The same procedure was followed with nearly the same pressure and rates obtained. The production rate varied greatly, but the 90-day test was 92 BOPD and 35 BWPD. The major difference in the two jobs was that 100 sacks of cement were used in the second well instead of 75 sacks.

The third example was an injection well which had a direct channel to a producing well. The producer and the injection well had both been fractured. The channel was probably created hydraulically. The volume of the fracture was calculated prior to the job to have a capacity of about 160 bbl. The same procedure was used as above but 600 sacks of cement (approximately 140 bbl of slurry) were used.

The annulus pressure was zero throughout the treatment at 3 BPM. The pressure on the tubing varied from 850-2600 psi with an average pressure of 1000 psi throughout the job. This job was done in two stages due to the spotting valve cutting out. The first stage used 200 sacks and the second stage used 400 sacks.

SUMMARY

The use of radioactive fluids and an interface has produced results in wells in the Levelland-Sundown area which have not been obtainable in the past. The interface technique is not new, but its use has been revised with new technology. It permits selective treating in both producing and injection wells. Interfacing improves treating of the zone by achieving much deeper selective penetration.

Cement squeeze jobs are also improved by the interface technique due to more selective placement of cement. The jobs are complicated and a little more expensive than conventional squeeze jobs, but the results usually justify the added cost.

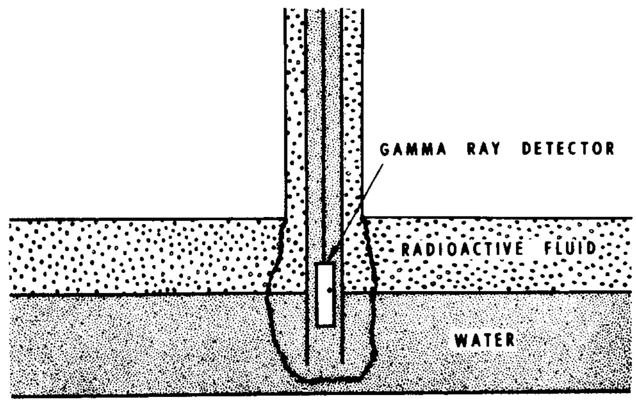

FIG. 3—ESTABLISHING INTERFACE FOR SQUEEZE TREATMENT