A New Approach to Selective Stimulation

By DAVE KEMP

Cardinal Chemical, Inc.

INTRODUCTION

Long open-hole or heavily perforated intervals with stringers of varying porosities and permeabilities have always been difficult stimulation problems. In the majority of instances treatments have been staged, continuously, with various types of blocking agents. Only after the job was complete, could any down-hole evaluation of the success of the diverting agents be estimated. Obviously, critical information such as the extent of the formation treated per stage, communicated zones, channeling behind the pipe, etc. was unavailable until after the treatment was over.

TREATMENT TECHNIQUE

A recent development utilizing a temperature survey immediately **after each stage** has afforded the immediate evaluation of the stage. This technique provides information from which following stages may be designed. As each subsequent stage is pumped, it in turn is evaluated and again the proper amount of blocking material is calculated.

As an example, a typical fracture treatment of 40,000 gal. of gelled water with 40,000 lb frac sand is planned to stimulate four separate zones of varying porosities and permeabilities in a long open-hole completion. It is desired to treat each zone with 10,000 gal. fracture fluid.

MATERIALS REQUIRED

The necessary materials for the above treatment are as follows:

(1) The predetermined volume of fluids and additives desired to treat the entire formation
(2) Sufficient fluid volume to flush the treating string after each stage
(3) Sufficient fluid to carry anticipated volumes of blocking materials
(4) Normal amount of pumping and auxiliary equipment required to perform stimulation operation
(5) A logging unit equipped with a temperature differential log, (TDL).

PROCEDURE

The procedure would be as follows:

(1) Run a temperature differential log. (See Fig. 1). Figure 1 illustrates the temperature conditions of the well prior to treatment.

(2) Pump 10,000 gal. frac fluid at desired rate and displace.

(3) Run TDL to evaluate extent of treated zone. (NOTE: Logging runs are started immediately after the well has apparently stabilized. Several runs are usually required to determine decay rates, screening out ghost anomalies, and to define the actual zones treated. Also, at this time, the over-all success of the previous blocking stage is determined. The time required for this process may vary from as little as 30 minutes to several hours).

Figure 2 illustrates the extent of the treated zone.

(4) Size the amount of plug necessary to plug off the treated interval.

(5) Repeat the above procedure until all zones have been stimulated. (See Figs. 3, 4 and 5).

Figure 3 indicates that the plug has diverted the treatment into zone 3.

Figure 4 illustrates that the third stage of treatment has entered zone 1 and the plugging of zones 2 and 3 was effective. Figure 5 is the last logging run after all four stages have been pumped and indicates successful treatment of all four zones.

The preceding example is one of illustration only, based upon the use of a treatment fluid with a temperature lower than bottom-hole temperature. Treating fluids can be any of those fluids used in acid or frac stimulation. Blocking agents can be the granular materials commonly used or, in severe cases, temporary blocking gels.

However, rock salt is the most commonly used blocking agent due to its handling ease and low cost.

To date, approximately 500 operations of this type have been performed in the Permian and Anadarko Basins. It is estimated that 90 per cent of these treatments have been successful in terms of treating all of the productive zones present and the resultant increase in production. These jobs have included all types of stimulation treatments common to fields within the two areas mentioned. This technique does not promise to be a cure-all for our stimulation problems; however it does provide the operator more knowledge of what is taking place during the treatment so appropriate measures may be taken during the treatment operation. This will undoubtedly save a great deal of remedial expense in the future if it is known that all zones have been sufficiently stimulated.

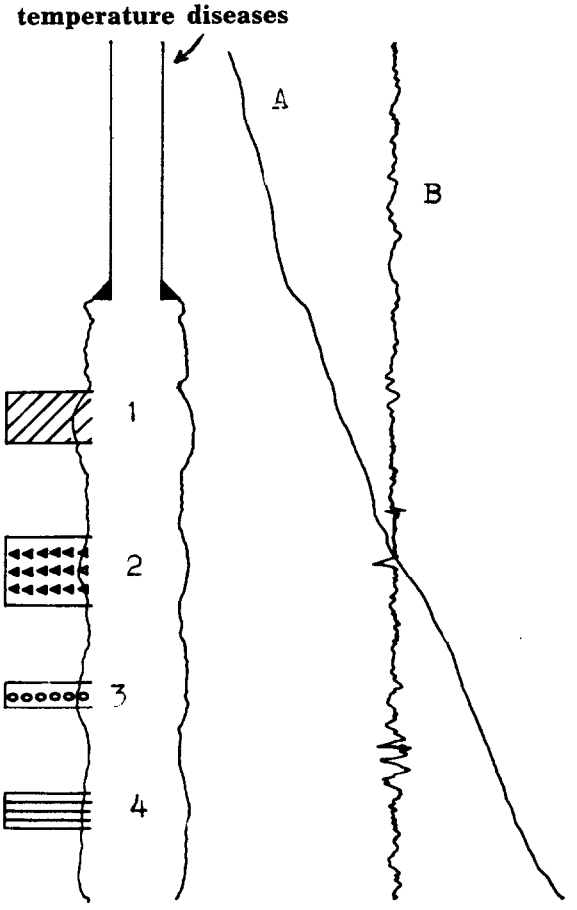

FIGURE 1 Line A is the gradient curve. Line B is the differential curve.

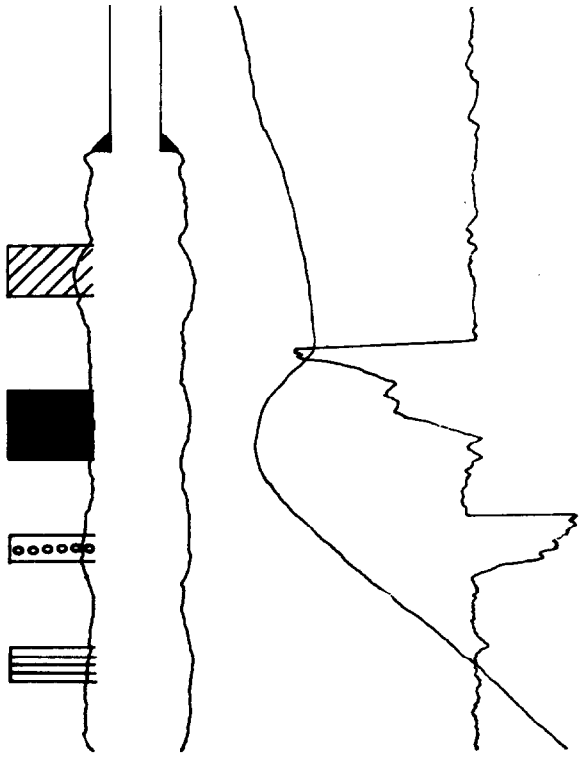

FIGURE 2 indicates treatment in zone 2.

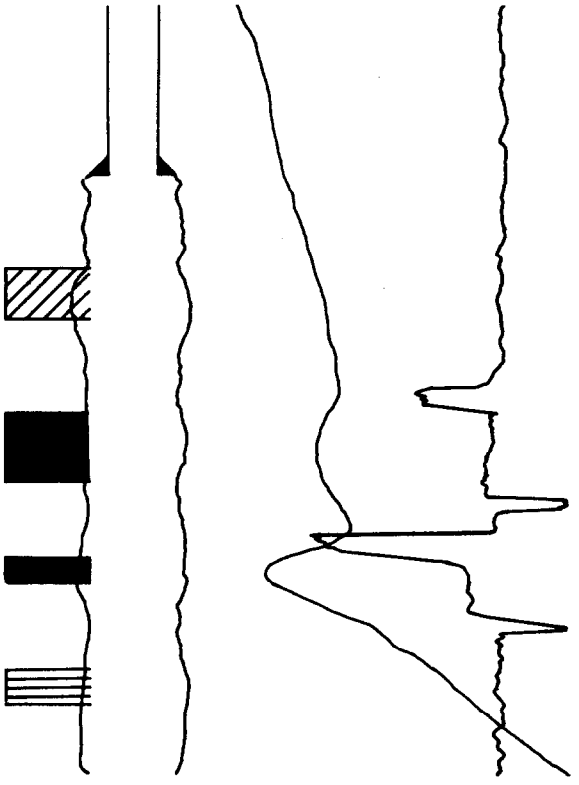

FIGURE 3 indicates diversion of treatment into zone 3.

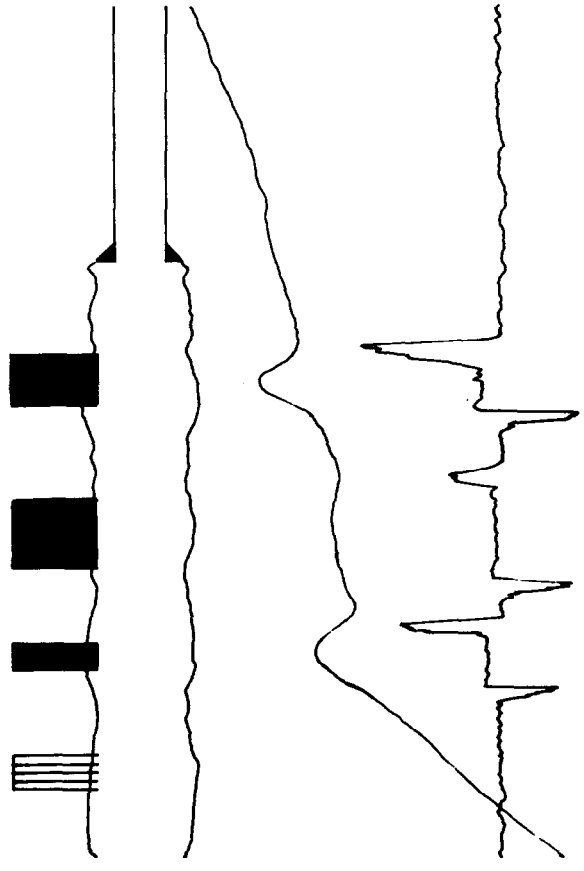

FIGURE 4 illustrates that the third stage of treatment has entered zone one and the plugging of zones 2 and 3 was effective.

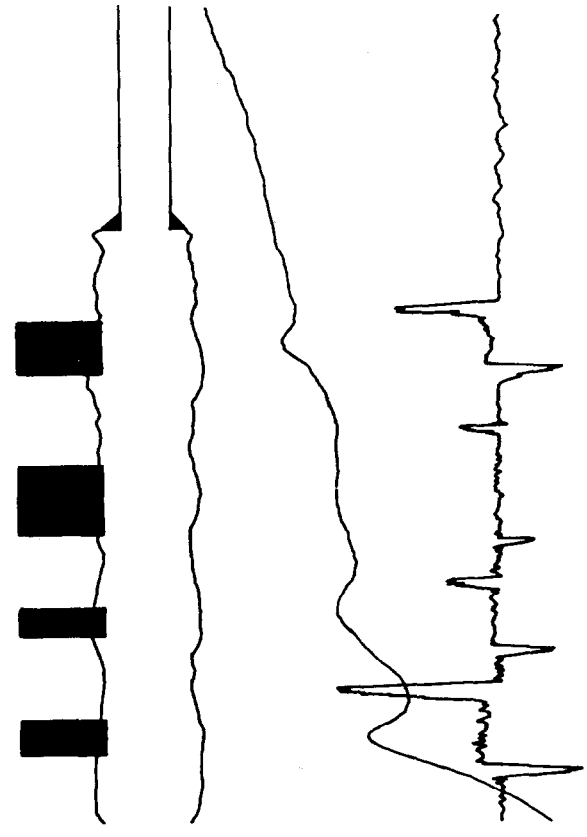

FIGURE 5 is the last logging run after all 4 stages have been pumped and indicates successful treatment of all 4 zones.

CASE HISTORIES

Well #1: An injection well in the Prentice Field in Terry County was taking 300 BWPD at 1100 psi. The other injectors in the field were taking 1000 BWPD at 1100 psi.

The objective of the treatment was to increase the injectivity to the level of the other injectors.

The well had 54 ft of gross pay with four sets of perforations with four shots per ft. The base log indicated the bottom portion of zone no. 4 (See Fig. 6) was taking fluid. Each frac staged consisted of 10,000 gal. gelled water. The log after stage 1 indicated treatment in zone 4. A diversion block was run prior to stage 2 and the frac was found in zones 1 and 3. Another block was run prior to stage 3 diverting the frac into zone 2. After the reservoir pressured-up the well was taking 1013 BWPD at 1100 psi.

Well #2: A well in the San Andres formation in Gaines County with an open hole section making 12 BOPD had a high GOR (9000:1). It was desired to treat the well without increasing gas production. The base log was run prior to treatment. The first stage consisted of 250 gal. 15 per cent HCI followed by 50 bbl heated lease crude. The temperature survey indicated treatment in the gas cap. A mixture of oil-soluble wax beads was run prior to the second stage of 1500 gal. HCI. The treatment was diverted into the oil zone. Current production is 132 BOPD with a 2250:1 GOR.

ACKNOWLEDGEMENT

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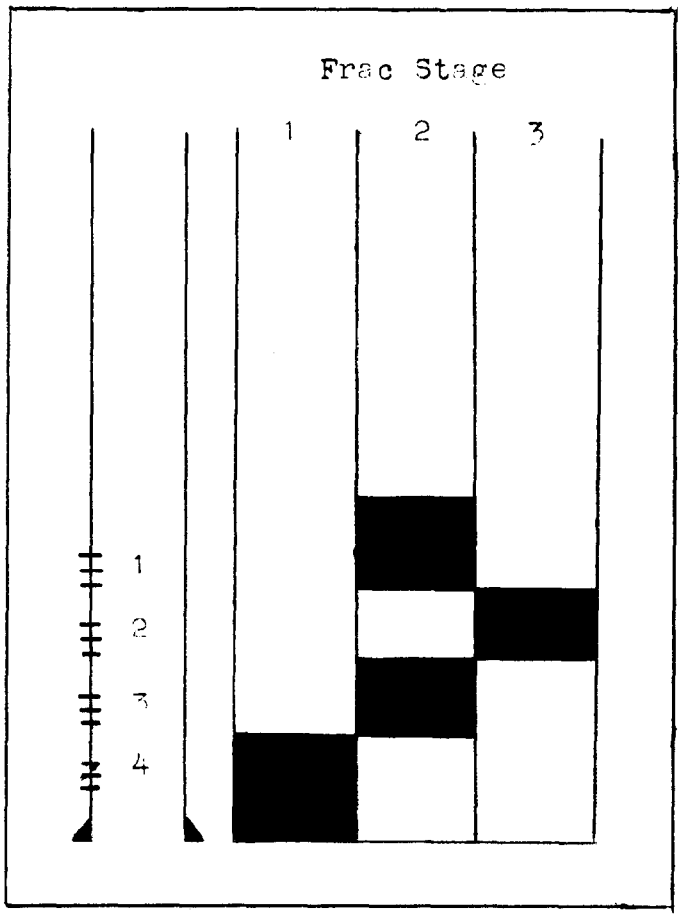

FIGURE 6 The shaded areas indicate the extent of treatment of each frac stage.