A LOW-TEMPERATURE BREAKER FOR FASTER WELL TURN-AROUND AND BETTER WELL CLEAN-UP

P. E. CLARK and HOMER SKELTON
Dowell Division of Dow Chemical U.S.A.

ABSTRACT

Low-temperature (50° to 100°F) wells present a special problem for the application of fracturing technology using current highly viscous water-gels. As the gelling-agent concentration increases, the gells require more time to effect a complete breakdown of the gel. This tends to slow turn-around time after treatment and, in some cases, inhibits complete clean-up. Techniques have been developed to circumvent this problem, but they involve lowering the gelling-agent concentration. This has also resulted in lowering the proppant concentration and increasing the pump rate. Several studies have shown the importance of high total prop volumes in good stimulation treatments and the importance of controlling pump rate for good frac height control. Thus, stimulation treatment performance has not been as good as it might have been in higher gelling-agent concentrations; higher propping-agent concentrations and lower pump rates could have been used.

A new low-temperature breaker for waterbased gells has been developed that allows the controlled breaking of gelled fluids over a temperature range of 50°F to 100°F. Field results are available to show that this breaker is effective in low-temperature wells. A summary of this data will be presented.

INTRODUCTION

In the past few years, the increase in the price of oil has made stimulation by hydraulic fracturing of low-temperature reservoirs more profitable. The definition of a low-temperature reservoir is as follows: any producing formation with a bottom-hole static temperature of 125°F or less. At low temperatures, several problems arise that are not prevalent at higher temperatures. Most of the problems arise from the difficulty in chemically breaking down the gel structure of the fracturing fluid after the fracturing treatment.

The objective of a fracturing treatment is the creation of a highly permeable flow channel for the flow of oil or gas into the wellbore. To form these flow channels, it is necessary to place the propping agent into the producing intervals efficiently. The pack should extend outward from the wellbore, while propping as much of the producing interval as possible. Basically, there are two ways to carry prop with a fluid: 1) high fracture-fluid velocities (high pump rates), 2) fluid viscosities high enough to minimize prop settling.

PUMP RATE

While high pump rates improve the prop carrying ability of a fluid, they also may cause the fracture to grow upward or downward out of zone. This growth could produce a poor prop distribution in the producing interval.

FLUID VISCOSITY

Therefore, the alternative—high-viscosity fluids—is a better, more controlled method of accomplishing the objective of good prop distribution.

Traditionally, wells with low bottom-hole static temperatures have been treated with fluids having a viscosity of 20 cps or less. The low viscosity was necessary for rapid clean-up and maximum fluid recovery. The low viscosity made carrying high concentrations of propping agent difficult, often resulting in screen outs. The top line in Figure No. 1 is a degradation curve of a gel made from a guar-based gelling agent at a concentration of 20 lb per 1,000 gal without the use of a chemical breaker. The lower line depicts the same gel with a standard breaker. For the purpose of this discussion a solution with a viscosity of 10 cps or less will be considered broken. Figure No. 1 demonstrates that

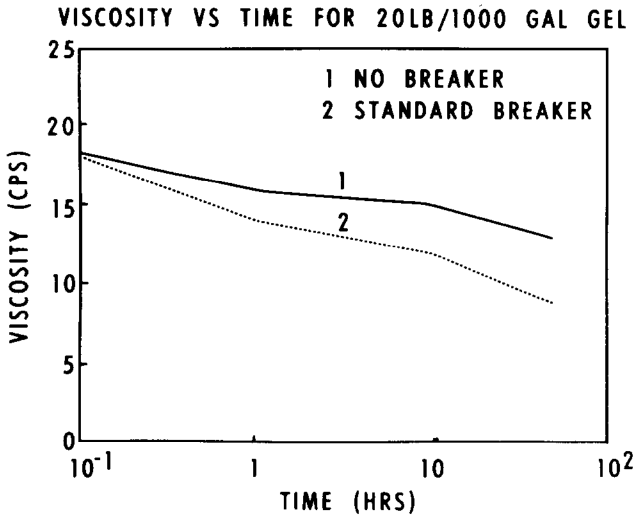

FIGURE 1—BREAK CURVES FOR 20 LB OF GELLING AGENT PER 1,000 GAL OF WATER GEL. TEMPERATURE = 80°F

the gel in the absence of breaker is not broken after 50 hours. When in the presence of a breaker, 30 hours is required to break the gel.

Now let us examine a typical treatment using a thin fluid in a well with a bottom-hole static temperature of 80°F. Table 1 contains the output from a computer run at two pump rates. The plots in Figure No. 2A and 2B are representations of the prop distribution that could be expected. These prop packs tend to be relatively short and do not give deep-zone coverage. For these examples, we have assumed a fracture height of 2 ft of height per BPM injection rate. Thus at a pump rate of 10 BPM the fracture height will be 20 ft. Repeating the same analysis for a linear and crosslinked 40 lb per 1,000 gal gel, it will be possible to compare treatment designs for low-temperature wells.

The data presented in Figure Nos. 3 and 4 suggest that even in the presence of breaker, reduction in

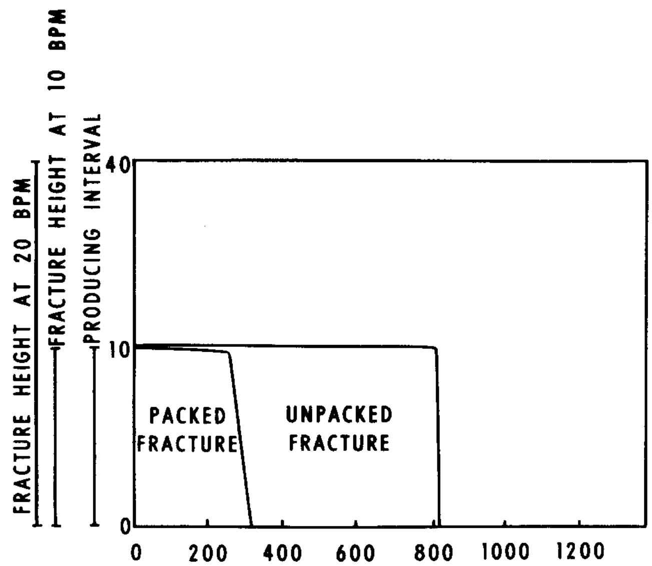

FIGURE 2A PROP PACK PROFILE FOR A 20 LB PER 1,000 GAL GEL PUMPED AT 10 BPM

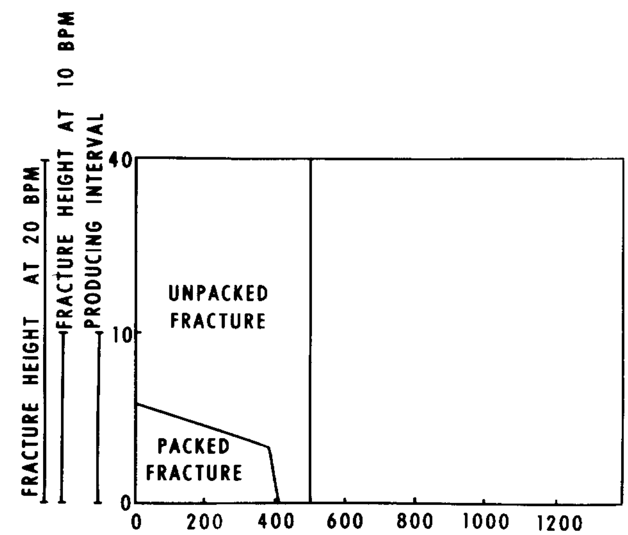

FIGURE 2B PROP PACK PROFILE FOR A 20 LB PER 1,000 GAL GEL PUMPED AT 20 BPM

TABLE 1—COMPUTER CALCULATED FRACTURE PARAMETERS FOR VARIOUS JOB DESIGNS

Gel Concentration (Lb/1,000 gal)	Pump Rate (BPM)	Fracture Height (Ft)	Prop Concentration Lb/gal	Pack Height Well bore	Pack Height Max. Pack Extension	Fracture Length (Ft)	Maximum Pack Extension (Ft)	Average Slurry Height (Ft)
20	10	20	2	19	19	820	330	0
20	20	40	2	12	7	504	420	0
40	10	20	3	19	19	1000	500	0
40	20	40	3	16	1	740	740	0
40 Crosslinked	10	20	5	2	1	1100	1100	17
40 Crosslinked	20	40	5	1	0	750	750	38

Note: Total volume of each treatment was 30,000 gallons.

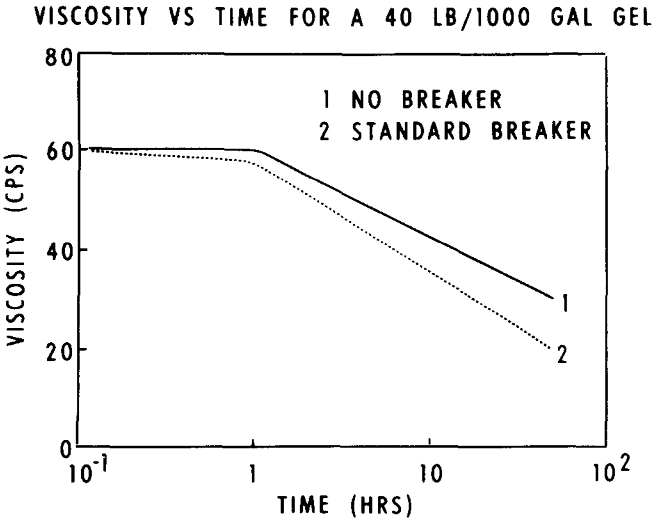

FIGURE 3 BREAK CURVES FOR A 40 LB OF GELLING AGENT PER 1,000 GAL OF WATER GEL. TEMPERATURE = 80°F

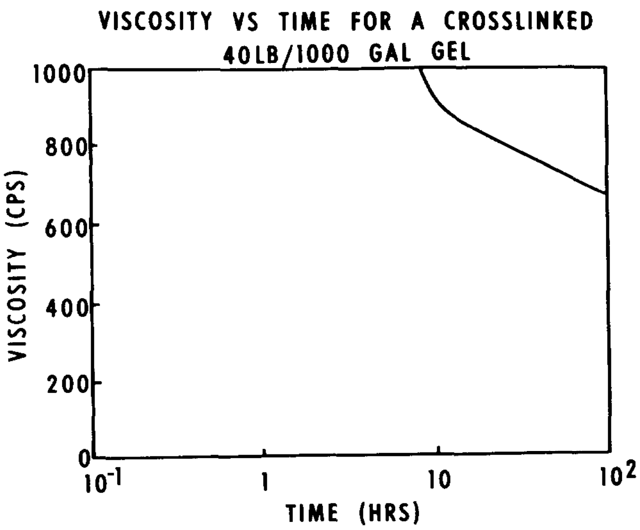

FIGURE 4 BREAK CURVE FOR A CROSSLINKED 40 LB OF GELLING AGENT PER 1,000 GAL OF WATER GEL. TEMPERATURE = 80°F

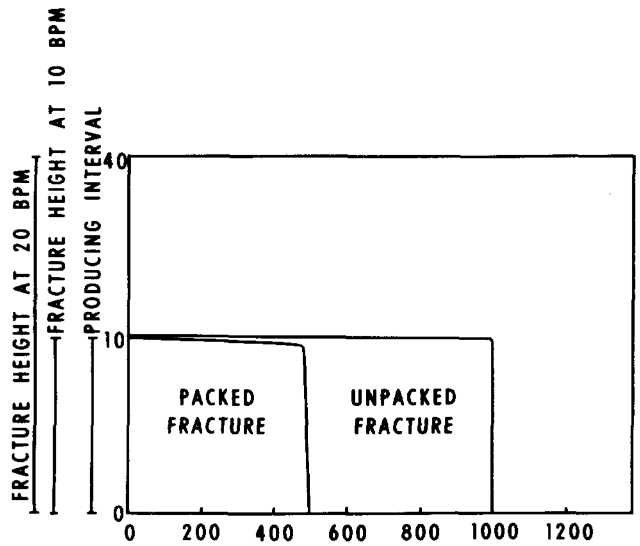

FIGURE 5A PROP PACK PROFILE FOR A 40 LB PER 1,000 GAL GEL PUMPED AT 10 BPM

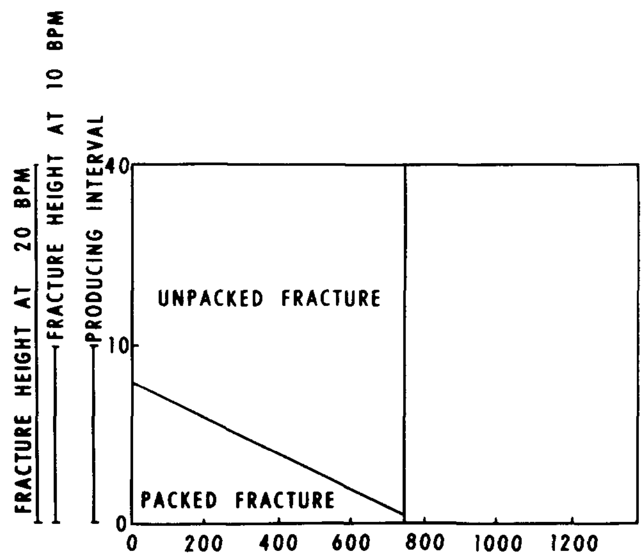

FIGURE 5B PROP PACK PROFILE FOR A 40 LB PER 1,000 GAL GEL PUMPED AT 20 BPM

viscosity is slow, indicating in its absence no significant break to occur in more than 24 hours. In reference to Figure Nos. 5A and 5B and 6A and 6B the pack shows that the distribution of propping agent is better for both of the above-mentioned gels than it is for the 20 lb per 1,000 gal gel (see Table 1 for the data).

The need for a low-temperature breaker for waterbased gelling agents is evident from the above data. Any material that is used as a breaker should be chemically and environmentally safe, reasonably priced, and effective over a wide temperature range. Another problem that must be overcome is controlling the chemistry of the reactions over a range of mix water and operating conditions. We have found it necessary to develop breakers for both crosslinked and linear gels (Breaker A and Breaker B). Figure No. 7 shows the data for a 20 and 40 lb per 1,000 gal linear gel. The use of Breaker B in these systems provides a quick, effective break at 80° F. If longer working times are required, a second component can be added to the mix water to retard

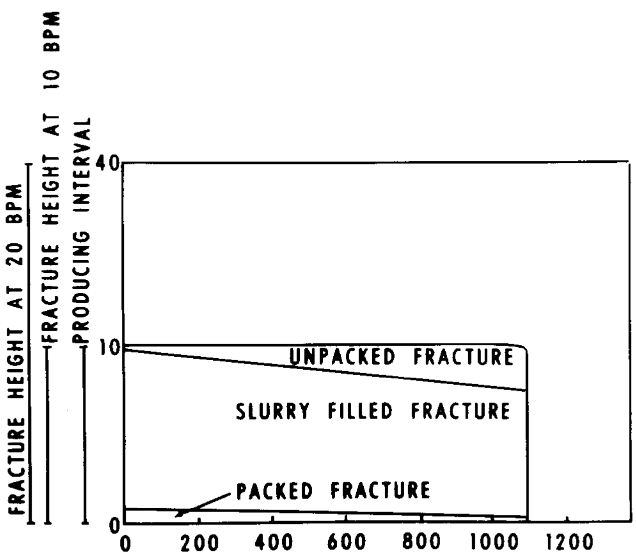

FIGURE 6A PROP PACK PROFILE FOR A 40 LB PER 1,000 GAL CROSSLINKED GEL PUMPED AT 10 BPM

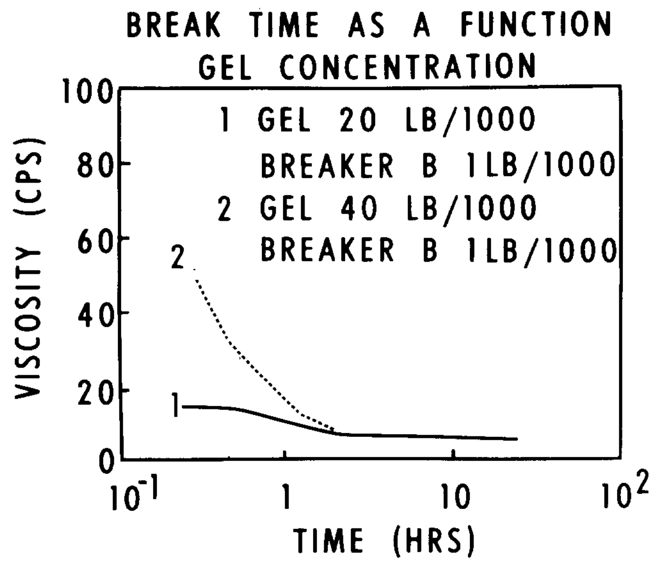

FIGURE 7—BREAK CURVES FOR LINEAR WATERBASED GELS USING BREAKER B. TEMPERATURE = 80°F

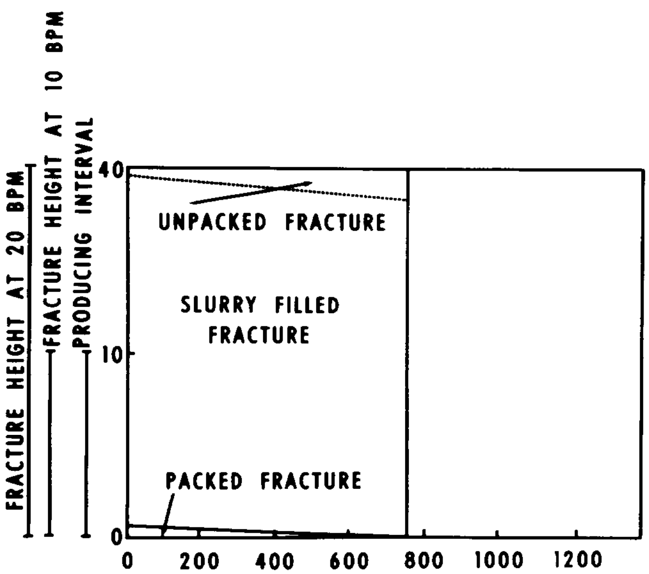

FIGURE 6B PROP PACK PROFILE FOR A 40 LB PER 1,000 GAL CROSSLINKED GEL PUMPED AT 20 BPM

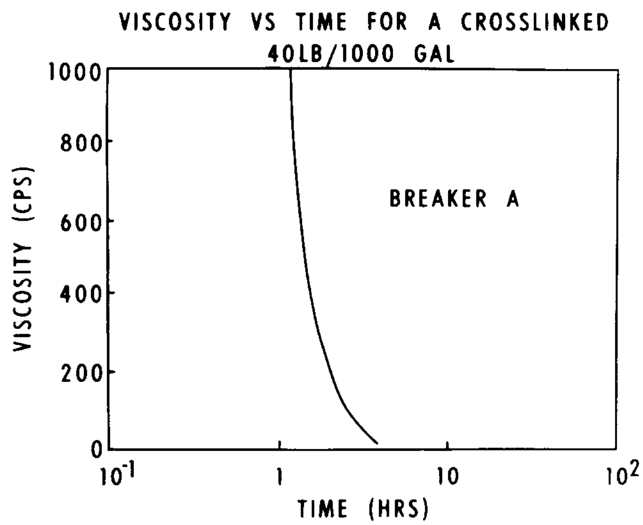

FIGURE 8 BREAK CURVES FOR A CROSSLINKED 40 LB OF GELLING AGENT PER 1,000 GAL OF WATER GEL WITH BREAKER A

the break for up to 3 hours. The curve in Figure No. 8 shows that crosslinked gels can be broken effectively at low temperatures. This extends the useful range of these systems into lower temperature reservoirs.

CONCLUSION

Comparing all of the data, it becomes evident that better treatments result from higher viscosity fluids pumped at lower rates. Also, prop distribution in the producing interval is more efficient while fracture-height growth is more controlled. The use of low-temperature breakers has opened up a whole new dimension in the hydraulic fracturing of low-temperature reservoirs.