Fracturing Fluid Efficiency With Fluid Loss Control

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The fracturing method to be discussed is not new. It is a process introduced to the oil industry in 1955 and was used sparingly at the outset, but has experienced tremendous growth in the past three years.

The discussion will be divided into three parts:

1. Presentation of the theory of low fluid loss fracturing.
2. Demonstration of the fluid loss properties of current fracturing fluids.
3. Interpretation of fluid loss test results in comparing fracturing fluids.

However, before the three main topics are to be discussed a brief history of fracturing fluids should be considered. Fracturing began in 1949 with the initial fracturing fluids consisting of viscous fuel oils, gelled kerosene, or napalm. For the next five years little change took place in the nature of fracturing fluids, but the first major change occurred in 1954 with the advent of fluid loss additives. Prior to this time it was believed that viscosity was necessary to prevent sandouts; however, this belief was soon disproved by the use of fluid loss additives in lease crude.

By 1959, fracturing had changed tremendously and, today, with economical and efficient fracturing fluids, many jobs in excess of 100,000 gallons are being performed. In fact, in 1959, a major oil company in South Texas fractured a well in one stage with 180,000 gallons of lease oil and put away 270,000 pounds of sand with the aid of a fluid loss additive. Then, in the last five years the use of fluid loss additives has more than quadrupled; and, in 1960, over 125 million gallons of fluid with fluid loss additive were pumped.

THEORY OF LOW FLUID LOSS FRACTURING

First, the mechanics of fracture extension as illustrated in Fig. 1 should be investigated. The left portion of this figure shows the result of using high fluid loss fracturing fluids. This fluid is lost from the fracture to the formation which resulted in high sand concentrations within the fracture. This lost fluid cannot be used to

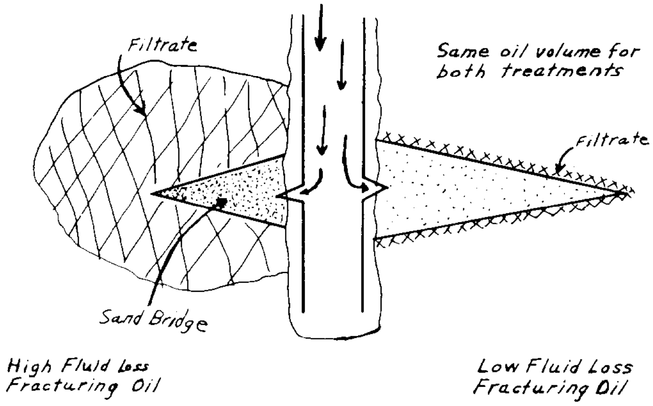

FIGURE 1

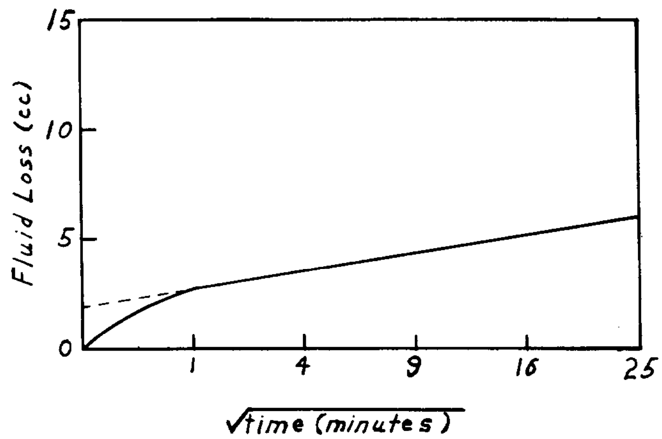

FIGURE 2

extend the fracture, and the excessive sand buildup within the fracture can result in a sandout. It is possible for the surface area of the fracture to be extended to a point where fluid is lost to the formation at the same rate as it is being pumped. When this point is reached, the fracture cannot be extended any further. This fact is true whether the fracture is horizontal or of a vertical nature.

The right portion of this figure demonstrates the benefits of fluid loss control. The fluid is confined to the fracture and does the job for which it was designed — that of creating more fracture area. And it should be noted that with the same oil volume, a longer fracture is obtained with the low fluid loss fluid.

DEMONSTRATION OF FLUID LOSS PROPERTIES

The test which will be used here has been developed by an API sub-committee for measuring fracturing fluid efficiency. The test conditions require a pressure differential of 1000 psig and a temperature of 125° F. Test results are recorded as cubic centimeters of fluid lost through the filter in a 25-minute interval. Readings are taken at one, four, nine, sixteen, and twenty-five minutes, because of the convenient square roots of these numbers, and the fluid loss is plotted on the Y-axis. In this manner a straight line curve is obtained from the fluid loss reading, and from this curve, as will be seen later, the spurt loss (instantaneous loss) and the rate at which fluid is lost to the formation will be able to be determined.

It should be noted that the lease oil, which demonstrates no fluid loss control in filter cell I, has, following the addition of 0.05 pounds per gallon of fluid loss additive, an extremely low fluid loss in cell II. Likewise, it can be seen that gelled lease oil and refined oil, both yielding high fluid loss values in cells III and V, can also be converted to low fluid loss fracturing fluids (cells IV and VI) by the addition of a fluid loss additive. This API test

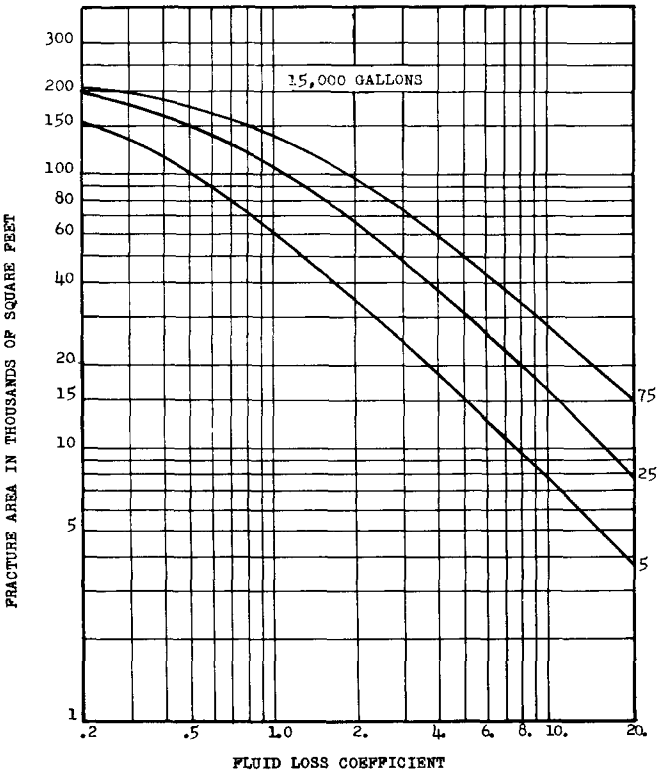

FIGURE 3

emphatically shows the ability of this fluid loss additive to control fluid loss.

First, however, should be added a word about the way in which a fluid loss additive functions. The additive does not dissolve, for if it did it would be of no use. Instead, it disperses into extremely small particles, down in the micron size range, and is carried by the oil into the newly created fracture system. As the spurt loss — loss which takes place immediately upon breaking down the formation — occurs, the fluid loss additive is deposited in a very thin film on the faces of the fracture, and this deposit continues as long as new fracture area are exposed. From this it may be seen how important is the spurt loss: the spurt loss is easily the most critical part of a fracturing treatment.

The mark of a good fluid loss additive is one which has a very low spurt loss. The thin impermeable seal which the additive imparts on the fractured face will stay there only so long as there is pressure holding it; and as soon as any flow-back commences, the additive re-disperses and flows back out through the highly permeable fracture sand which was put into the fracture. This movement occurs even in wells where there is no bottom-hole pressure.

INTERPRETATION OF TEST RESULTS

Fig. 2 is a plot of fluid loss vs. the square root of time utilizing data from the fluid loss test. The slope (m) of this fluid loss line is an indication of the rate of fluid loss to the formation during fracture treatment. The spurt loss (Vsp), represents the amount of fluid lost prior to establishment of fluid loss control and is obtained by extrapolating the fluid loss line back to the Y-axis. For this example, it is shown that M = 1.0 and Vsp = 2.0.

$$C = 16.4 \frac{m}{a}$$

C = Fluid Loss Coefficient
a = Area of Filter (Sq cm)
m = Slope of the Fluid Loss Curve

This equation gives a measurement of the efficiency of a fracturing fluid after spurt loss has ceased. The lower the fluid loss coefficient, the more efficient is the fluid. Using the previously stated values for m and Vsp with a filter area of 24.5 sq cm, a fluid loss coefficient of 0.7 is obtained.

The effect of this fluid loss coefficient is interpreted by use of Fig. 3, which is a plot of fluid loss coefficient bs. fracture area with injection rate as parameters for a fluid volume of 15,000 gal. This plot is graphical verification of the value of low fluid loss. For example, with a fluid loss coefficient of 5.0 at an injection rate of 25 BPM, the treatment would result in a theoretical fracture area of 30,000 square feet. By referring to our example coefficient of 0.7, it is seen that a theoretical fracture area of 130,000 sq ft would result using the same injection rate and volume. Therefore, the fracture area has been more than quadrupled by reducing the fluid lost to the formation.

The fracture area of 130,000 sq ft, however, has not been corrected for spurt loss. Fig. 4 is a nomograph for spurt loss correction. For the example problem where the fluid loss coefficient is 0.7, injection rate is 25 BPM, spurt loss is 2.0, and volume is 15,000 gal, a correction factor of 85 per cent is obtained: instead of the 130,000 sq ft of fracture area previously indicated, only 85 per cent of that figure or 110,000 sq ft would actually be created.

The importance of spurt loss can be illustrated by another sample calculation. A fluid with the same continuous loss (C = 0.7) at the same injection rate and volume, but with a spurt loss from the fluid loss test of 10 ml, would result in a correction factor of about 47 per cent; the 130,000 sq ft of fracture area uncorrected for spurt loss would actually be reduced to only 47 per cent of that area, or about 61,000 sq ft. A high spurt loss of 10 ml has resulted in cutting the fracture efficiency in less than one-half.

These calculations show that, when comparing fracturing fluids, it is imperative to examine both the fluid loss coefficient and the spurt loss. A careful examination of the correction factor for spurt loss will reveal that a low fluid loss coefficient is of no value unless accompanied by a low spurt loss.

This presentation has been designed to show how fluid-

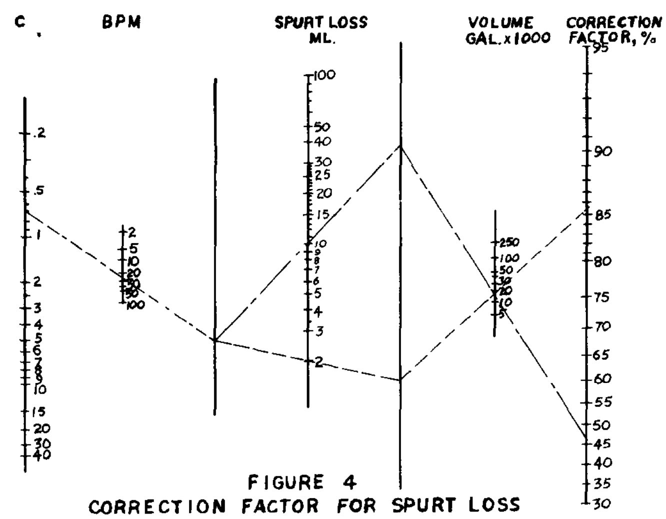

FIGURE 4
CORRECTION FACTOR FOR SPURT LOSS

loss control is important in the evaluation of fracturing fluids and how data from the API RP39 test can aid in comparing these fluids. This test, in conjunction with theoretical calculations and actual field results, gives concrete evidence supporting the increasing trend toward the use of fluid loss additives in hydraulic fracturing.

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