Engineering Break-Through Provides Fracture Treatments of Greater Efficiency

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ABSTRACT

Fracturing has always been regarded as a highly technical type of stimulation treatment, and even the earliest fracture jobs were performed under carefully controlled conditions. A large number of variable factors controlled the efficiency and ultimate success of any treatments. During the past ten years of field application, the greatest emphasis has been placed upon only two or three of these variables. Failure to observe all pertinent factors has, in some cases, caused considerable disappointment and economic waste.

An engineered "Frac-Guide" has now been assembled which allows preplanning treatments for improved results. This is accomplished by proper evaluation of the many variables present on every job.

This new approach to fracture treatment design has been used on over 400 jobs throughout the United States and Canada with outstanding success. This paper discusses how these variables can be determined and interrelated to provide well operators with treatments of the greatest economy and efficiency.

INTRODUCTION

Fracture treatments are defined as those treatments where a liquid under hydraulic pressure is used to produce fracture openings into a reservoir rock for the purpose of creating high capacity flow channels between the well bore and distant points in the reservoir. A solid material is carried along with the liquid to provide fracture propping after pressure is reduced.

After ten years of applying this method to improve well production (although hundreds of different fluids at variable pressures and injection rates have been used), some very important questions remain unanswered. Recent correlation of data from over 50,000 performed treatments, combined with accepted mathematical calculations presented to the industry by representatives of major oil companies, now makes it possible to accomplish the following tasks with a high degree of accuracy:

1. Determine the orientation of the fracture plane existing after treatment.
2. Calculate the square feet of reservoir rock exposed to the fracture channel by any performed treatment.
3. Evaluate each fracturing fluid to determine how much work each will perform, for economical comparison.
4. Estimate reservoir penetration by use of accepted flow patterns.
5. Control propping agent size and amount to provide open fractures of sufficiently high capacity for the reservoir treated.

"AREA-VOID" CALCULATIONS

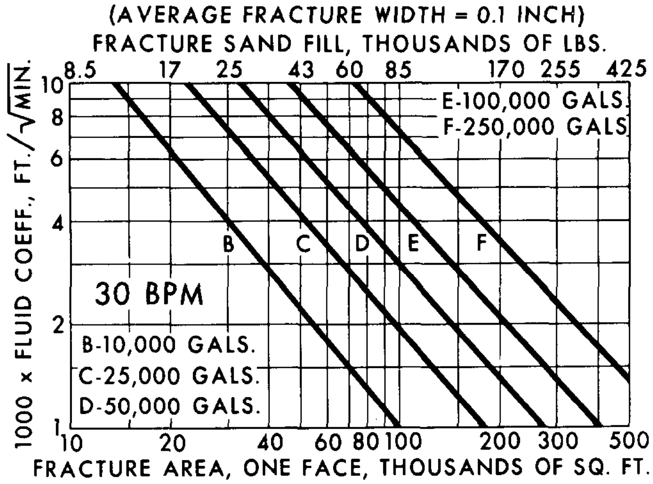
To determine the area of the fractures opened up by a treatment, and the volume of the resulting void, the fracturing fluid must be matched with the reservoir into which it is injected, to determine how much of the liquid is lost to the reservoir matrix and how much is retained within the fracture system as working liquid. This matching is represented after calculation, by a fluid coefficient. The larger this number, the greater the fluid leak-off to matrix and, thus, the less efficient is the fluid for creation of fracture "area-void." Reservoir data necessary to accomplish this matching process for all commercial fracturing fluids is as follows:

Reservoir matrix permeability
Reservoir porosity
Reservoir pressure
Reservoir fracture gradient
Reservoir temperature
Reservoir fluid compressibility
Reservoir fluid viscosity.

Fig. 1 shows the relationship of this fluid coefficient to fracture "area-void" at a constant injection rate of 30 BPM. Increasing the injection rate moves the fluid volume curves to the right, while a decrease in injection rates moves the volume curves to the left.

EFFECT OF FLUID COEFFICIENT & VOLUME ON FRACTURE AREA AT CONSTANT INJECTION RATE

(AVERAGE FRACTURE WIDTH = 0.1 INCH)

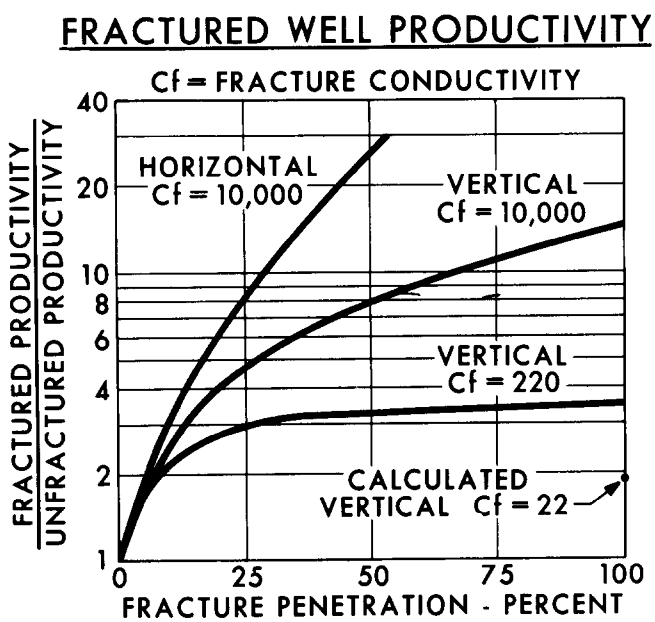


Properties of the fracturing liquid which must be matched to the reservoir properties are viscosity and wall-building ability. A series of technical data charts, entitled "Engineered Fracturing Recommendations," which simplifies the matching of suitable liquids to reservoir properties, has been developed by the Dowell Division of The Dow Chemical Company.

FRACTURE PLANE

From analysis of past treatments and data collected on critically controlled experiments, the fracture gradients of Permian Basin reservoirs were found to range between 0.40 and 1.80 psi per foot of depth. For those reservoirs having a fracture gradient of 0.7 or less, the resulting fractures were predominantly in a vertical plane. An insufficient number of reservoirs in the Permian Basin display a fracture gradient between 0.7 and 1.0 to make accurate predictions in this range. Those formations exhibiting a fracture gradient greater than 1.0 received fracture treatments predominately in the horizontal plane.

Vertically fractured reservoirs often present many production problems after treatment, because no method is presently available to limit the extent of the vertical plane. This allows the opened fractures to extend into undesirable zones above or below the pay zone, often resulting in high gas ratios or high water production. For reservoirs of this type with a limestone matrix, controlled acidizing may offer the best approach to gaining maximum production with the least amount of damage to the reservoir.



FRACTURE CAPACITY

Fracture capacity is defined as the relationship of fracture millidarcy feet to matrix permeability. Fig. 2 shows how this fracture capacity becomes of tremendous importance as reservoir penetration is increased. To assure that the fracture capacity remains high, stimulation treatments should provide packed fractures containing propping agent of sufficient permeability. Fracture packing can be accomplished by matching the fluid coefficient to the liquid volumes and sand volumes used with a particular injection rate, as previously shown in Fig. 1.

TREATMENT PERFORMANCE

Knowledge of fracture gradients and fluid coefficients allows prejob planning for greatest economic return, and job performance with a minimum of difficulties. Prejob planning can now include:

1. Close estimation of maximum surface pressure.
2. Calculation of liquid volume for greatest stimulation.
3. Estimation of amount of propping agent required to fill created void.
4. Choice of economical and effective injection rates.
5. Choice of most economical liquid, based on work performed.
6. Critical estimation of reservoir penetration for reservoirs under water flood.

REFERENCES

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