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NEW EXPLOSIVE FRACT RING METHOD S SAFE, EFFECTIVE

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# New explosive fracturing method is safe, effective

## Explosive slurries are displaced into the well bore and safely detonated to create highly productive random fracturing


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**15-second summary**

A new material has been developed for safe application in explosive fracturing of gas and oil wells. Field tests show profitable increases in 90% of wells treated. Here's how the explosive slurry is placed and detonated.


A HIGH ENERGY EXPLOSIVE for gas and oil well stimulation has been recently field tested in over 100 wells. Blasting agents designed originally for open pit mining were modified into self-contained slurries, complete with encapsulated air, that can be safely placed through tubing.

Outstanding feature of explosive stimulation is the random fracturing of formation rock around the well bore. This treatment may be particularly effective in hard, low permeability formations where conventional hydraulic fracturing contacts a relatively small volume of rock.

### RANDOM FRACTURING

Explosive fracture treatments greatly increase well productivity by creating many random fractures in the formation. Hydraulic fracturing, on the other hand, will only create or extend relatively few fracture planes. Normally, hydraulic fracturing results in 2 to 3 fold increase. Such increases are considered successful, but they are far below possible theoretical values because of limited fracture flow paths.

Rubble-izing and random fractures created by explosive fracturing in competent rocks should provide extremely high flow capacity. This will especially benefit formations where flow patterns or natural permeability cannot be contacted or intersected by hydraulic fracturing methods.

A summary of wells in which random fracturing by blasting agents may be more effective than conventional methods is shown in the accompanying table. In general, the blasting technique is applied to production limiting problems which are within 50 feet of the well.

### MATERIAL DEVELOPMENT

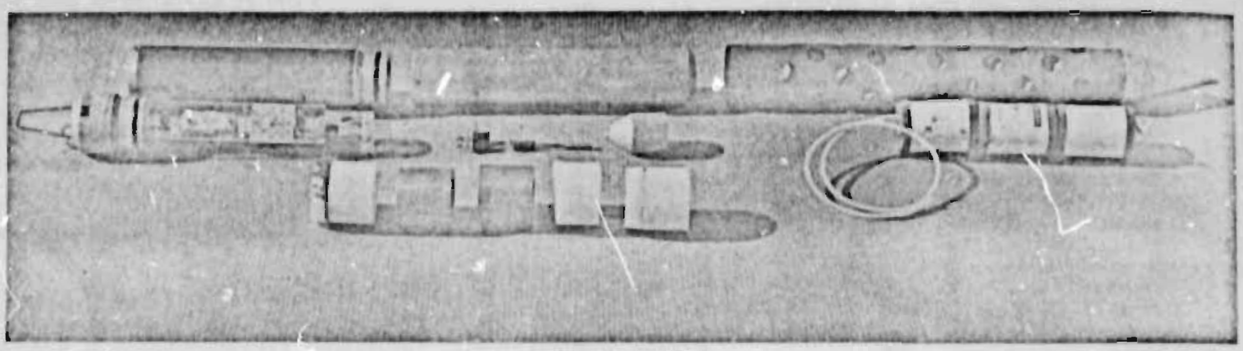
Explosive fracturing was the first well stimulation method. It was the only stimulation tool for nearly a half century after which acidizing and hydraulic treatments were adopted, primarily for safety.

Although nitroglycerin was an adequate material for explosive fracturing, it could not be safely used in deep wells. Gelatins and solid explosives did not have enough unit energy or rock coupling properties when dumped into a wellbore. Therefore, many excellent applications for well "shooting" were bypassed.

In the early 1950s, there were attempts to combine explosive and hy-

## *Where explosive fracturing is applicable . . .*

- Long open hole intervals with multiple pay zones which complicate hydraulic treatment.
- Formation scaling causing permeability reduction up to several feet from the well bore.
- Gas sands with sensitivity to hydraulic treating fluids.
- Older wells with poor casing or cement jobs which limit use of hydraulic treatments.
- Remote areas where conventional equipment is difficult or expensive to locate.
- Productive zones close to water where barriers usually break down with hydraulic pressure.
- Reservoirs with fracture patterns definitely oriented toward nonproductive areas, gas caps, water injection wells, etc.
- Closely spaced wells designed for maximum recovery from limited drainage area.



**TIMING DEVICE-DETONATOR** used to set off Stratablast "A" slurry in well bore. Slurry is displaced into the well bore opposite the pay zone through tubing with pressure from special truck mounted cylinders. Tubing is then pulled and the timing device is lowered into the slurry by wireline. The hole is tamped with gravel and detonation occurs according to the timed schedule. High metal content of slurry keeps material in place with good bore-hole contact.

draulic fracturing. Basically, these were hydraulic fracture treatments in which the propping agent was a *pelletized solid explosive*. After placement, the explosive was detonated with a jet perforating gun.

Theoretically, this type treatment can give excellent results with a deeply penetrating random fracture pattern. It remained in development for several years and many wells were treated. Results were limited because the explosion did not propagate into the reservoir from the wellbore. Materials used were not hazardous, but the process was more expensive than conventional well shooting since pumping, mixing and perforating equipment were required.

Another approach used *hypergolic fluids*. Such fluids, though not explosive themselves, will explode when mixed. The technique was to displace one fluid into the formation, follow it with a small volume of spacer, then displace the second liquid to initiate detonation.

This treatment was feasible in both deep and shallow wells, but premature detonation problems have not yet been solved. Usually, only a small amount of the second fluid can be displaced before detonation occurs, limiting penetration of the formation for less than maximum results. However, limited research is continuing on this project.

**New blasting agents** have eliminated safety hazards, and placement techniques have improved enough to make well shooting economically attractive. It is now considered an effective stimulation tool.

Agents are slurries of ammonium nitrate, water, air and metal originally developed for open-pit mining and similar applications. They provide excellent power ratings, safety in handling and good borehole coupling (conforms to and closely contacts the rock with no air pockets).

A few problems prevented general application in gas and oil wells. Elevated hydraulic pressures in deep wells made safer slurry systems undetonatable and frequently, the density of these slurries did not allow placement under well brines.

Continued research developed a means of encapsulating air needed for detonation and propagation into thin-walled, high strength glass microbeads. This allowed retention of air in proper form and volume ratio for explosive reaction under elevated pressures. Other changes permitted an increase in metal content of slurry, normally to 30%, to increase density.

These modifications yielded a material that was applicable to gas and oil wells. The accompanying table shows relative power ratings of this system, called Stratablast "A," and other commonly used blasting agents.

**Average relative power rating of explosives. Rating is a combination of initial shock energy and "bubble" ratings.**

| | |
|---|---|
| Stratablast "A" | 1.800 |
| Ammonium nitrate fuel oil | 0.944 |
| TNT | 0.770 |
| High explosive non-metalized | 0.770 |
| High explosive iron-metallized | 0.545 |

## FIELD APPLICATION

Initial field placement tests were done in shallow wells, less than 500 feet deep by lowering flexible plastic bags of slurry on a shooter's hook. Detonations at shallow depths allowed observation of wellbore enlargement and well re-entry problems. Offset holes were easily drilled to observe fracture patterns and permeability improvement.

To further develop placement techniques, wireline dump bailers were used to place bagged material in deep wells. This permitted evaluation of explosive effect in deep reservoirs. However, multiple wireline trips and poor coupling to the rock face in fluid filled holes made better placement mandatory.

Pressure displacement and spotting of blasting agent through tubular goods with bag type material was impossible. A change in the gelling agent gave the slurry sufficiently low friction coefficient to allow placement through tubing.

**Placement and detonation.** Service equipment consists of truck-mounted, high-pressure cylinders equipped so that blasting agent slurry can be pressure displaced into tubing and the wellbore through the zone to be stimulated. Using this approach, placement efficiency has increased from →

60% to nearly 100% of calculated hole capacity.

After placement of blasting agent, tubing is removed and a timing device-detonator is lowered into the slurry. The hole is stemmed or tamped with gravel, and detonation is observed from a safe distance.

Through research work in shallow wells, an empirical expression was developed to closely represent effective fracture penetration for shots up to several thousand pounds. Example calculations are shown in the accompanying table.

**Examples of calculated random fracture extension using an empirical formula derived from tests in shallow wells.**

| Well Bore (inches) | Length of Charge (feet) | Weight of Charge (pounds) | Avg. Random Ext. (feet) |
|---|---|---|---|
| 8 | 4 | 100 | 21 |
| 10 | 5 | 200 | 30 |
| 14 | 7 | 550 | 37 |
| 20 | 10 | 1,600 | 53 |
| 28 | 14 | 4,500 | 72 |

**Well clean-out** after explosive fracture treatment can be more complicated than with hydraulic fracturing, especially in wells that will not sup-



## About the authors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port a full fluid column. Stratablast "A" will normally generate a rubble heap of ⅛ to 1-inch particles equivalent to 20 times the volume of explosive used. Rubble is usually removed for maximum production.

Wells supporting a full fluid column can usually be circulated clean. Gas wells, with an adequate supply line nearby, may also be blown clean with a bit on bottom for agitation.

Low fluid level oil wells present the greatest problem. Techniques used on these wells are expensive. Some require cable tool bit and bailer. Circulation with foam has also been used.

**Field results** from 103 wells have been analyzed. Blasting agents were placed with bailer or pressure displacement equipment on the last 75 wells. Earlier jobs used lower grade explosives with steel lines, electrical shooting lines or bailers. Treatments involved gas and oil producers, water injection wells and dry holes.

For 60 wells with production data prior to explosive fracturing, 90% had increased production. Of total jobs, 75% were profitable. Three wells were damaged so that some production was lost. One of these was successfully reshot.

Actual economic improvement cannot be fairly judged by these early treatments as many wells made available for testing this new process, with its inherent risk, generally had low production already and poor potential. Often these wells showed high "percentage" increase with relatively small absolute change.

Although risk involved with this type of stimulation will continue to be higher than with hydraulic treatments, the process has excellent potential in many reservoirs where effects of random fracturing are great enough to justify treatment.

The following limitations of the present system should be considered for any possible application:

- Wells must be static with hydrostatic pressure at the bottom less than 1,500 psi. Where "pressure rated blasting material" is available, pressures up to 3,000 psi can be tolerated.
- Bottom-hole temperature must be between 65° and 250° F.
- Formation must be exposed in open-hole. ■

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