

United States Patent [19]**Lozanski**[11] **3,713,487**[45] **Jan. 30, 1973****[54] EXPLOSIVE FRACTURING AND
PROPPING OF PETROLEUM WELLS****[75] Inventor: Walter R. Lozanski, Calgary,
Alberta, Canada****[73] Assignee: Dri-Frac Limited, Brooks, Alberta,
Canada****[22] Filed: Dec. 30, 1970****[21] Appl. No.: 102,945****[52] U.S. Cl. 166/280, 166/299, 166/308****[51] Int. Cl. E21b 43/26****[58] Field of Search.....166/280, 299, 308****[56] References Cited****UNITED STATES PATENTS**

3,533,471	10/1970	Robinson	166/308
3,399,727	9/1968	Graham.....	166/280

3,456,589	7/1969	Thomison.....	166/299 X
3,593,793	7/1971	Kelseaux	166/299 X

Primary Examiner—James A. Leppink
Attorney—Stevens, Davis, Miller & Mosher**[57] ABSTRACT**

A method of stimulating the flow of petroleum fluids in a well. Explosive fracturing of the petroleum formation adjacent to the well is carried out in the presence of a propping agent, such as glass beads, sand or aluminum particles. The propping agent-explosive combination is preferably surrounded by granular ammonium nitrate explosive to insure the absence of voids in the well bore. The method avoids the necessity for the use of liquids for fracturing or propping, and this is advantageous in cases where the formation would be damaged by the use of liquids such as water or drilling fluids.

4 Claims, No Drawings

EXPLOSIVE FRACTURING AND PROPPING OF PETROLEUM WELLS

This invention relates to a method for stimulating the flow of petroleum fluids in a well.

Fracturing of oil and gas well formations has been successful for the purpose of increasing the flow of petroleum fluids. Such fracturing can be effected by injecting a liquid into the well under sufficient pressure to fracture the formation. This fracturing can also be effected by the use of explosives such as ammonium nitrate. Such fractured formations may be further stimulated by forcing a propping agent into the fractures under pressure. If the propping agent is of sufficient size and strength, it has the ability to hold the fractures open so that oil and gas may pass more freely from the formation into the well bore.

DISCUSSION OF THE PRIOR ART

There are many prior patents and publications disclosing the techniques for fracturing formations with various explosives and for propping fractured formations open, and other publications disclosing the propping of such fractured formations, for example, U.S. Pat. No. 3,270,815 to Osborn et al., issued Sept. 6, 1966; U.S. Pat. No. 3,155,162 to Flickinger et al., issued Nov. 3, 1964; Canadian Patent No. 621,362 to Yahn, issued June 6, 1961; Canadian Patent No. 681,297 to McGuire et al., issued Mar. 3, 1964; Canadian Patent No. 643,201 to Hradel et al., issued June 19, 1962; Canadian Patent No. 791,631 to Griffith et al., issued Aug. 6, 1968 and U.S. Pat. No. 3,270,813 to Gilchrist, issued Sept. 6, 1966. None of these prior publications disclose the presently claimed method, nor do they suggest the present invention.

THE PRESENT INVENTION

It is an object of the present invention to provide an improved method for stimulating the flow of petroleum fluids from a petroleum formation into a well. The present inventor has found that if an explosive charge is mixed with a propping agent and this mixture is exploded in the well bore, it fractures the formation by the force of the explosion and simultaneously propps the formation open. This can be achieved without the use of any fluids and thus can in certain cases represent an important advantage.

The present invention therefore provides a method of stimulating the flow of petroleum fluids in a well comprising the step of fracturing the petroleum formation adjacent the well by the action of an explosive charge in the presence of a propping agent. The propping agent may be chosen from the group consisting of glass beads, propping sand, metal particles such as aluminum particles, or ceramic particles, as preferred embodiments.

In a preferred aspect, the present invention provides such a method comprising the steps of locating an explosive charge and a propping agent in the bore of the well, filling the void between the wall of the well bore and the explosive charge composition with further granular explosive, and detonating the charge. The preferred granular explosive is ammonium nitrate and the ammonium nitrate may have a particle size of 8 to 12 on the U.S. Standard Scale. The charge will preferably be stemmed with sand for the purpose of containing the explosive. It is found very satisfactory to

stem with sand to a height at least 75 percent the length of the explosive column. The propping agent which is associated with the explosive charge will preferably constitute about 2 to 5 percent by volume of the void space in the explosive zone.

In a preferred form, the explosives, such as dynamite, together with the propping agent, such as glass beads, is placed in a plastic container provided with a detonator, such as Geogel (trademark), Procore (trademark), Xactex (trademark), attached to a primer cord, which runs to the surface. The plastic container is lowered to the explosive zone and the void space remaining is preferably filled with pellets or prills of ammonium nitrate explosive.

A suitable ammonium nitrate explosive is Amex-II (trademark) which is a free flowing plant mix of ammonium nitrate prills and oil, along with additives to reduce generation of static electricity, and to prevent setting-up during storage. An orange dye is also incorporated.

A preferred propping agent is glass beads such as the type referred to in the above mentioned U.S. Pat. No. 3,270,813, column 1, line 55 to column 2, line 9 thereof, which is incorporated herein by reference.

It is difficult to determine the amount of explosive required to fill a well bore to the height desired. This is important so that the top of the charge may be located at the desired level. When drilling with air, the well bore normally remains in gauge and no special problem ensues. The volume of explosive can then be calculated knowing the diameter of the bit used in drilling. For example, if a 4 $\frac{1}{4}$ inch diameter bit is used, the volume required to fill the hole to a desired level may be calculated arithmetically. If the hole does not remain in gauge, the caliper survey may be run to determine the exact hole size. Alternatively, the type of the charge may be located by lowering the bar on a wire line.

Prior to filling the well bore with explosives, the well-head is removed and the well pressure is bled off. Should a high volume well be encountered in which the flow rate will not dissipate sufficiently to allow the explosives to be lowered from surface, some other means of filling the well bore may be used.

For example, a hose having a diameter of 1 $\frac{1}{2}$ to 2 inches may be lowered to the bottom of the well bore and the explosive may be placed in this manner. Alternatively, the dump bailer may be used or the explosive may be loaded into the well bore through a lubricator.

EXAMPLE 1

Milk River Formation in Alberta, Canada, is a prime gas bearing formation for which the present technique is well suited. The Milk River formation is a complex sand - shale matrix located at a depth of approximately 900 to 1,100 feet and is approximately 300 feet thick. It contains sweet, dry gas. The reservoir pressure is low, in the vicinity of 450 psi.

The presence of gas in the Milk River formation has been known since the early 1900's when the Canadian Pacific Railway discovered this gas bearing formation while searching for water. Because of the low rates of deliverability, the main users of the Milk River gas heretofore have been individual farmers, the Canadian government National Defence Department station at Suffield, and local utility companies.

The low deliverability of the Milk River formation apparently resulted from damage caused from the use of drilling fluids. Experimentation with rock samples taken from the Milk River zone indicated the sensitivity of the soft shales, which turn to mud when exposed to water.

The advent of air and gas drilling has had a dramatic effect upon the deliverability of gas from the Milk River zone. With the great potential of the Milk River formation as a source of natural gas, any technique which would improve the economics of producing gas from this reservoir would be of great interest and benefit to the natural gas industry.

The above history of the Milk River formation is presented as background data for the present process. As it is important to minimize or eliminate the exposure of the Milk River zone to any fluid, the present technique of filling the hole without the necessity for using any liquid as a carrying agent is unique and important in preventing damage to the formation.

In addition to the above effect fluids have upon the Milk River formation, it is an accepted fact that when inducing a fracture by hydraulic means and filling the fracture with a proppant, formation damage results from the introduction of the fracturing fluids and additives into the formation. However it is normally expected that the increased permeability of the reservoir rock in the vicinity of the well bore will override the damage created by the fluids. In the present technique, no such damage is introduced into the formation. Since no foreign fluids are introduced into the formation and well bore, as no fluids are pumped into the formation, none have to be recovered after the stimulation program is completed. The explosion technique results in the establishment of random fracture patterns which may contact gas reserves which might not otherwise be drained. Though the well owner may desire to remove the rubble from the well bore, this is not necessary, as the permeability of the rubble zone is much greater than the reservoir rock, and will not effect the deliverability of the well.

A sinker bar was lowered on a wire line to measure the exact length of the well bore. A detonating string was made up consisting of a tube containing glass beads, a Geogel dynamite and detonator, Procore primers, spaced over the interval to be stimulated. The above material was fused with a primer cord. A detonating string was lowered into the well bore and located across the zone to be treated. A sufficient volume of ammonium nitrate - fuel oil explosive (Amex-II) was dumped from the surface to fill voids between the walls of the well bore and the detonating string to a point a few feet above the top of the detonating string. An explosive package was stemmed with sand to minimize the amount of energy travelling up the well bore, being careful not to suppress the explosion to the extent that the well bore might be damaged.

The explosion was detonated from the surface by attaching the primer cord to detonating wires located approximately 20 to 50 feet into the well bore to reduce the possibility of fire.

The wells in the field showed a great increase in flowability after such treatment.

EXAMPLE 2

A procedure similar to that set forth in Example 1 was carried out on a well designated as Berl Bantry 10-1-19-14 W 4th.

Flow rate prior to stimulating:

July 13 — Gas flow through a flow prover containing a $\frac{1}{8}$ inch orifice plate —

flowing rate and pressure after 24 hours — 70 MCFD and 187 psig.

Absolute open flow potential — 99 MCFD.

Flow rate after stimulating:

July 24 — 27 — Flow rate after 81.25 hrs. — 145 MCFD —

Flow pressure 51 psig

Absolute open flow potential — 151 MCFD

Percent increase in Absolute potential — 52.5 percent.

Flow rate after second stimulation:

Sept. 26 -29 — Flow rate after 71.25 hours — 182 MCFD

Flowing pressure 68 psig

Absolute open flow potential — 194 MCFD

Percent increase from pre-treatment — Absolute open flow potential 96 percent.

EXAMPLE 3

A procedure similar to that set forth in Example 1 was carried out on a well designated as Berl Bantry 6-6-9-13 W 4th.

Flow rate prior to stimulating:

July 12 — Gas flow through a flow prover containing a $\frac{3}{16}$ inch orifice plate

Rate of flow after 12 hours — 122 MCFD

Flowing pressure — 138 psig

Absolute open flow potential — 139 MCFD.

Flow rate after stimulating:

August 13 - 15 — Flowing gas through a flow prover with a $\frac{5}{16}$ inch plate

After 45 hours flow rate — 200 MCFD

Flowing pressure — 76 psig

Absolute open flow potential — 212 MCFD

Percent increase over pre-stimulation — Absolute open flow potential 52.6 percent.

Flow rate after second stimulation:

— Flowing gas through $\frac{5}{16}$ inch plate

After 72.5 hours — flow - rate — 197 MCFD

Flowing pressure — 74 psig

Absolute open flow potential — 212 MCFD

No improvement indicated with second stimulation. However, though no improvement in deliverability resulted from stimulation No. 2, it is believed the fracture pattern resulting from the second treatment will allow the well to retain its rate of deliverability and pressure for an extended period of years in comparison to a non-treated well.

EXAMPLE 4

A procedure similar to that set forth in Example 1 was carried out on a well designated as Berl Bantry 6-22-19-13 W 4th.

Flow rate prior to stimulating:

Sept. 14-17 — Flow rate after 70 hours — 40 MCFD

Flowing pressure — 100 psig

Absolute open flow potential — 45 MCFD.

Flow rate after stimulation:

Sept. 21 - 26 — Flow rate — 79 MCFD

Flowing pressure — 84 psig

Absolute open flow potential — 86 MCFD

Percent increase in Absolute open flow potential — 91.1 percent.

I claim:

1. A method of stimulating the flow of petroleum fluids in a well comprising the step of fracturing the petroleum formation adjacent the well by the action of an explosive charge in the presence of a propping agent, and in the absence of liquid, wherein the propping agent is chosen from the group consisting of glass beads, sand, and metal or ceramic particles, and wherein the explosive charge is stemmed with sand before detonation.

2. A method as in claim 1 comprising the steps of locating an explosive charge and a propping agent in the bore of the well, filling the void between the wall of the well bore and the explosive charge composition with further granular ammonium nitrate explosive, and detonating the charge.

3. A method as in claim 2 wherein the ammonium nitrate has a particle size of 8 to 16 on the U.S. Standard Scale.

4. A method as in claim 2 wherein the propping agent associated with the explosive charge will constitute about 2 to 5 percent by volume of the void space in the explosive zone.

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