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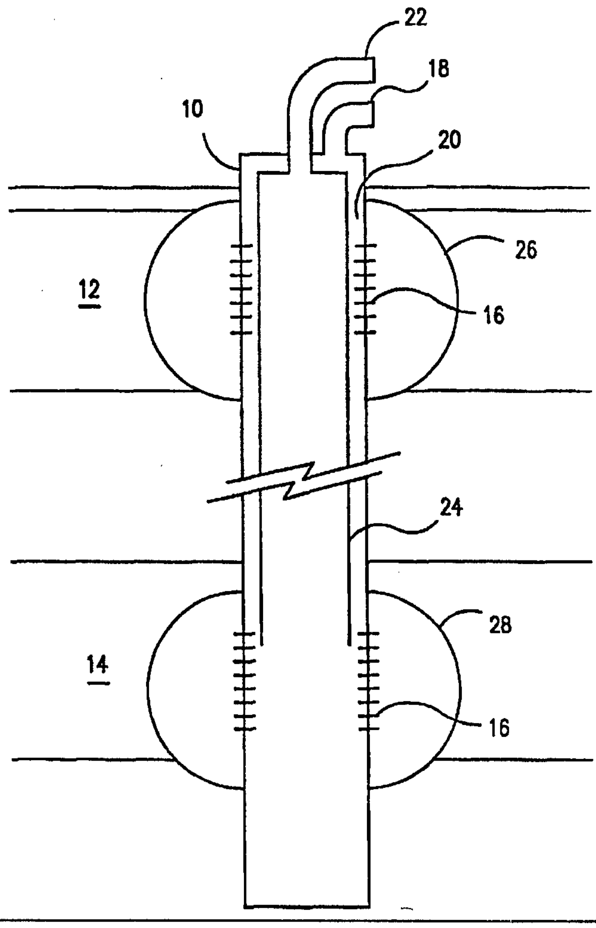
(54) Title: METHOD FOR HYDRAULICALLY FRACTURING SPACED FORMATION ZONES

(57) Abstract

Two spaced apart zones (12, 14) of a formation are simultaneously hydraulically fractured. A lower density fracturing fluid is injected into an upper zone (12) of the formation via an annulus (20) of a perforated wellbore (10, 16) communicating with the upper zone (12) thereby causing a fracture (26) to propagate. Simultaneously therewith, a higher density fracturing fluid is injected into a lower spaced apart zone (14) via a tube (24) within the wellbore (10) which fluidly communicates with the lower zone (14) thereby causing simultaneously the propagation of a second fracture (28). Neither fracture (26, 28) contacts the other although complete fracture growth is obtained.



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METHOD FOR HYDRAULICALLY FRACTURING SPACED FORMATION ZONES

This invention relates to a method for simultaneously hydraulically fracturing two spaced apart zones of a formation.

In the completion of wells built into the earth, a string of casing is normally run into the well and a cement slurry is flowed into the annulus between the casing string and the wall of the well. The cement casing slurry is allowed to set and form a cement sheath which bounds the string of casing to the wall of the well. Perforations are provided through the casing and the cement sheath adjacent the sub-surface formation. Fluids, such as oil or gas, are produced through these perforations into the well.

Hydraulic fracturing is widely practised to increase the production rate from such wells. Fracturing treatments are usually performed soon after the formation interval to be produced is completed, that is, soon after fluid communication between the well and the reservoir interval is established. Wells are also sometimes fractured for the purpose of stimulating production after significant depletion of the reservoir.

Hydraulic fracturing techniques involve injecting a fracturing fluid down a well and into contact with the subterranean formation to be fractured. Sufficiently high pressure is applied to the fracturing fluid to initiate and propagate a fracture into the subterranean formation. Proppant materials are generally entrained in the fracturing fluid and are deposited in the fracture to maintain the fracture open.

Several such hydraulic fracturing methods are disclosed is US-A-3965982, US-A-4067389, US-A-4378845, US-A-4515214 and US-A-4549608. It is generally accepted that the in-situ stresses in the formation at the time of such hydraulic fracturing generally favour the formation of vertical fractures in preference to horizontal fractures.

Wells completed through formations at multiple intervals always present a challenge for effective treatment. Frequently, various methods of zone isolation or diverting will be used in treating more than one well, especially if the zones of interest are separated by a few hundred feet. Wells which are perforated over several hundred feet in a single zone also create a challenge to treat effectively with well stimulation such as acidizing or hydraulic fracturing.

What it is needed is a method for hydraulically fracturing a formation having multiple intervals or zones which method does not require zone isolation. The invention seeks to achieve this objective.

According to the present invention there is provided a method for simultaneously hydraulically fracturing two spaced apart zones of a formation comprising:

a) injecting a first fracturing fluid into an upper zone of said formation via an annulus of a perforated wellbore communicating with said upper zone, which first fluid is injected at a pressure sufficient to initiate and propagate a first fracture within said upper zone; and

b) simultaneously injecting a second fracturing fluid, of higher density than the first fracturing fluid, into a lower zone of said formation, spaced from said upper zone, via an injection tube within the perforated wellbore that communicates fluidly with said lower zone, which second fluid is injected at a pressure sufficient to initiate and propagate a fracture within said lower zone.

Preferably, the lower and upper zones are spaced 50 to 300 feet (15 to 91 m) apart.

Desirably the density of the second fracturing fluid is about 0.5 lbs/gall (0.06 kg/dm^3) more dense than the first fracturing fluid.

The injection tube is preferably open-ended. It is also preferred that the first and second fluids do not mix while fracturing the zones.

The method according to the invention allows two spaced apart zones to be simultaneously fractured, thereby saving time and money.

The method according to the invention minimizes the effects of problematic fracture growth which occur in sequential fracturing in spaced apart zones.

The method according to the invention has the additional advantage that there is no need to mechanically isolate the zones from one another, eg by means of a mechanical packer.

In the method according to the invention the chances of one fracture contacting the other are considerably reduced compared with the techniques of the prior art. Complete fracture growth can be obtained in each zone while each fracture in that zone is confined to its own zone.

However, in the event that the first and second fluids do come into contact with one another, the differing density of each fluid ensures that the fluids are retained in their respective zones.

Reference is now made to the accompanying drawing, which is a schematic representation of a perforated wellbore in which hydraulic fracturing has been simultaneously conducted at two different spaced apart intervals of the formation.

In the drawing, a wellbore 10 has penetrated an upper zone 12 and a lower zone 14. The lower zone 14 is separated from the upper zone 12 by a distance of 50 to 300 feet (15 to 91 m) or more. The wellbore 10 communicates fluidly with the upper zone 12 and the lower zone 14 by perforations 16.

An annular space or annulus 20 is formed between the outside wall of the wellbore 10 and a tubing string 24 centrally located within the wellbore. The tubing string 24 communicates fluidly with the surface via a tubing string conduit 22. The tubing string conduit 22 communicates fluidly with a "frac" fluid supply means (not shown) and a pumping means (not shown). The annular space 20 fluidly communicates with the surface via an annulus conduit 18. The annulus conduit 18 is connected to a "frac" fluid supply means (not shown) and a pumping means (not shown).

In order to create two simultaneous fractures at different spaced apart zones of the formation, a first hydraulic fracturing fluid is directed down the annulus conduit 18 so as to enter the upper zone 12 through perforations 16. Hydraulic fracturing pressure is applied while simultaneously directing a second fracturing fluid which is more dense than the first fracturing fluid into the tubing string 24 via the tubing string conduit 22. The second fracturing fluid is directed by the tubing string 24 into the lower interval or zone 14 via the perforations 16.

Hydraulic fracturing fluid is continuously directed into the annulus conduit 18 and the tubing string conduit 22 so as to simultaneously enter the upper zone 12 and the lower zone 14 respectively. The rate and pressure of the hydraulic fracturing fluid entering upper zone 12 and lower zone 14 is at a rate and pressure sufficient to create one fracture 26 within the upper zone 12, while simultaneously creating another fracture 28 in the lower zone 14. The tubing string 24 is open-ended where it is located in an area adjacent to perforations 16 in wellbore 10 within lower zone 14.

As fracture 26 which is created in upper zone 12 propagates through that zone, it completely covers that zone. Additionally, since a lighter density hydraulic fracturing fluid is utilized in upper zone 12, less pressure is generated in that zone so the fracture does not propagate out of the zone 12. Less fracturing force is required because less pressure is generated in the zone 12 because its depth is less than that in the zone 14.

The Lower zone 14 is at a greater depth, therefore a higher density "frac" fluid is needed to generate greater pressures in the zone 14. Thus, the fracture 28 does not propagate upwardly into the zone 12 and problematic fracture growth is eliminated. If the fracture created in the zone 12 does communicate with the fracture in zone 14, the density differences will help keep fluids separated into their respective zones.

The first fracturing fluid enters the upper formation 12 at the same time that the second fracturing fluid enters the lower zone 14, with substantially the same injection rate and pressure, without mixing of the fracturing fluids; this leads to the consequence that a mechanical packer is not required to separate the upper zone 12 from the lower zone 14. Since both zones are being simultaneously hydraulically fractured, only one fracturing operation need be conducted in both zones. Conducting one hydraulic fracturing operation in both zones at the same time saves both time and money.

The effectiveness of fracturing at each zone of the formation can be determined by available methods. One such method is described in US-A-4415805. This method describes a multiple stage formation operation conducted with separate radioactive tracer elements injected into the well during the fracturing operation. After completion of the fracturing operation, the well is logged using natural gamma ray logging. The resulting signals are sorted into individual channels or energy bands characteristic of each separate radio tracer element. Results of the simultaneous fracturing operation are evaluated based on disbursement of the individual tracer elements.

The Wellbore 10 can be cased or uncased. If the wellbore is cased, the casing is cemented into the wellbore 10. Thereafter, the casing is selectively perforated in a manner so that in subsequent treatments, fluids being pumped therein will pass through all perforations at a substantial rate. While the pumping rate of the hydraulic fracturing fluid is formation dependent, it should be at least about 1 to about 10 barrels (0.16 to 1.6 m^3) per fracture. Perforations are made within wellbore 10 at a spacing of about 10 to about 100 feet (3 to 30 m) apart so a desired fracture spacing can be obtained. These perforations should comprise two sets of perforations which are simultaneously formed on opposite sides of wellbore 10. Preferably, these perforations should have diameters between about 0.25" to about 1" (6.4 to 25 mm). They should be placed circumferentially about the casing in the anticipated plane where it is desired to induce a fracture into the zone. The number and size of perforations are determined by the fracture treatment pumping rate and the pressure drop necessary to divert sufficient fluid through all the perforations to create simultaneously fractures in the upper and lower zones.
Fracture fluids which can be utilized herein include simple

Newtonian fluids, gels described as Power Law fluids, and acids. Use of acids as a fracturing fluid is discussed in US-A-4249609. Use of a gel as a fracturing fluid is disclosed in US-A-4415035. These fracturing fluids, as well as a method for fracturing a formation by limited entry, is disclosed in US-A-4867241.

Although the present invention has been described with preferred embodiments, it is to be understood that modifications and variations may by used within the scope of the appended claims.

Claims

1. A method for simultaneously hydraulically fracturing two spaced apart zones of a formation comprising:

a) injecting a first fracturing fluid into an upper zone of said formation via an annulus of a perforated wellbore communicating with said upper zone, which first fluid is injected at a pressure sufficient to initiate and propagate a first fracture within said upper zone; and

b) simultaneously injecting a second fracturing fluid, of higher density than the first fracturing fluid, into a lower zone of said formation, spaced from said upper zone, via an injection tube within the perforated wellbore that communicates fluidly with said lower zone, which second fluid is injected at a pressure sufficient to initiate and propagate a fracture within said lower zone.

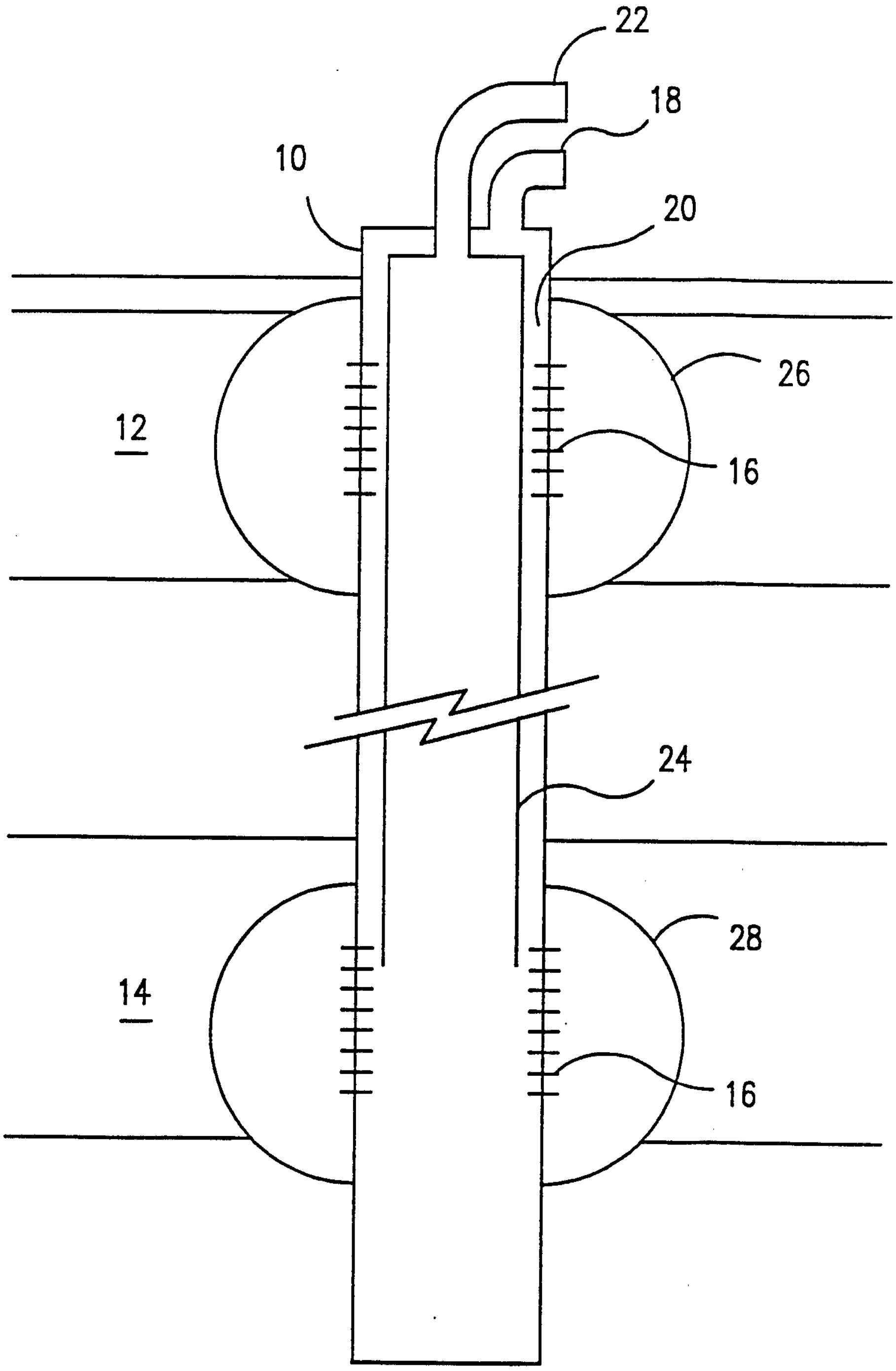
2. A method according to claim 1, wherein the lower and upper zones are spaced 50 to 300 feet (15 to 91 m) apart.

3. A method according to claim 1 or 2, wherein the density of the second fracturing fluid is about 0.5 lbs/gall (0.06 kg/dm^3) more dense than the first fracturing fluid.

4. A method according to claim 1, wherein the injection tube is open-ended.

5. A method according to claim 1, wherein the lower and higher density fracturing fluids do not co-mingle while fracturing the zones.

6. A method according to claim 1, wherein the first and second fluids do not mix while fracturing the zones.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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/13058

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :E21B 43/26
US CL :166/308, 250, 269
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 166/308, 250, 269, 281, 282, 271

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US, A, 3,954,142 (BROADDUS ET AL) 04 MAY 1976, Figs. 1-12.	1
A	US, A, 4,387,770 (HILL) 14 June 1983, col. 2, lines 20-45 and Figs. 1 and 2.	1
A	US, A, 4,415,035 (MEDLIN ET AL) 15 November 1983, Fig. 1 and col. 1, line 60 to col. 3, line 30.	1-6
A	US, A, 4,867,241 (STRUBHAR) 19 September 1989, col. 2, lines 15-61.	1

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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