

- [54] **WELL TREATING PROCESS USING SACRIFICIAL PLUG**
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- [73] Assignee: **Mobil Oil Corporation**, New York City, N.Y.
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- [52] U.S. Cl. **166/291, 166/294, 166/295, 166/305 R**
- [51] Int. Cl. **E21b 33/16, E21b 43/25**
- [58] Field of Search. **166/294, 300, 292, 166/291, 295, 194, 192, 193, 305 R; 137/72, 67**

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[57] **ABSTRACT**

The specification discloses a well treating process wherein a sacrificial plug is used to separate two treating fluids while they are being injected into a formation interval within a wellbore through a common tubing. The sacrificial plug is formed from material which will maintain its integrity while in the tubing but will decompose upon reaching its destination within the wellbore.

13 Claims, 2 Drawing Figures

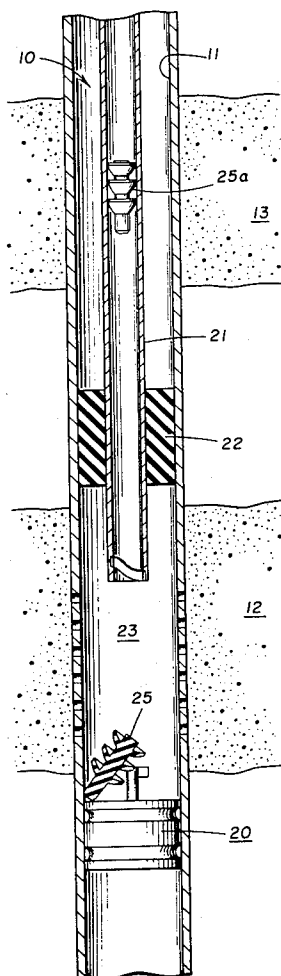


FIG. 1

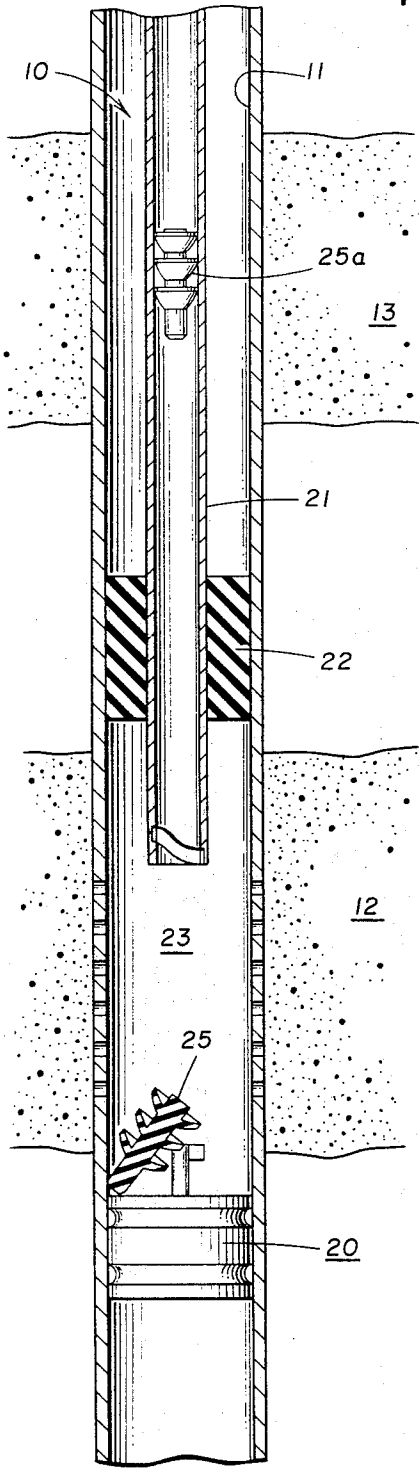
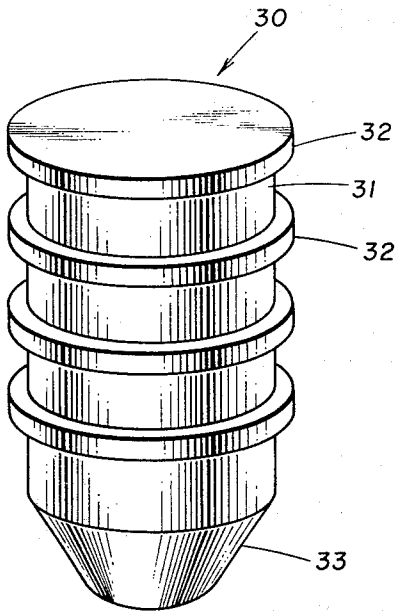


FIG. 2



WELL TREATING PROCESS USING SACRIFICIAL PLUG

BACKGROUND OF THE INVENTION

This invention relates to a method for carrying out a well treatment operation and more particularly relates to a method of carrying out a well treating operation wherein a sacrificial wiper plug is used to separate treating fluids while they are being pumped into the formation interval to be treated through the same tubing.

In completing a mineral producing well, e.g., oil or gas, it is sometimes necessary to treat one or more formations within the well to improve production therefrom. In many such operations, e.g., sand consolidation, more than one treating fluid must be injected into the formation interval which is being treated. Normally, to do this, the formation interval is isolated within the wellbore by means of packers which are set at both the upper and lower ends of said interval. The desired fluids are then injected into said interval through a tubing string which extends from the surface to the isolated area between the packers. Where more than one fluid is required, it is usually desirable to physically separate the fluids until they reach the formation interval so that they do not contaminate one another or cause a premature reaction between each other while in the tubing.

This physical separation is usually effected by solid wiper plugs which are inserted into the tubing between the various treating fluids. These plugs are pumped along with the fluids to the bottom of the tubing where they are either expelled out the bottom of the tubing or where they are caught in a "plug catcher" which is provided in the tubing.

In many instances, the formation being treated is of such thickness that it cannot be successfully treated in a single operation. Further, in some areas, a single wellbore may extend through several different overlying formations, each of which requires treatment. In such situations, for complete treatment of the wellbore, the individual treatment operation has to be repeated a number of times within the wellbore. This requires the packers to be moved within the wellbore to isolate a different interval for each operation.

Where the wiper plugs, mentioned above, are expelled from the tubing, they fall onto the lower packer where they normally cannot be retrieved and where they present problems to the releasing and repositioning of the lower packer. Where the plugs are caught in the tubing, the tubing string has to be completely removed from the well so that the caught plugs can be removed from the tubing before the tubing can be used for the next treatment operation. As will be understood, this pulling and rerunning of the tubing substantially adds to the time and expense of the overall completion of the well.

BRIEF DESCRIPTION OF THE INVENTION

In accordance with the present invention, there is provided a process for carrying out a well treatment operation wherein two or more fluids are injected through a single tubing string into the formation to be treated. Further, the process of the present invention allows the well treatment operation to be repeated at different levels within the wellbore without requiring the tubing

to be removed from the well and rerun before each repetition.

In the preferred embodiment of the present invention, the formation interval to be treated is isolated within the wellbore. This is done by sealing the wellbore below and above the formation interval with packing means. This packing means is preferably comprised of a bridge plug which is set at the lower end of said interval and an upper packer, mounted on a tubing string, which is set at the upper end of said interval.

As is known in the art, the bridge plug is carried to its position within the wellbore by the same tubing string which carries the upper packer. The bridge plug is set in the wellbore by manipulation of the tubing, after which the tubing is released from the bridge plug. The tubing string is then raised in the wellbore to the upper end of said interval where said upper packer is set by manipulation of the tubing. If the well is cased as it normally will be, a "through-tubing" perforator is lowered through the tubing into the isolated portion of the wellbore and actuated to perforate the casing to establish communication between the isolated wellbore and the formation interval to be treated.

The desired treating fluids are then injected into the formation one at a time through the tubing. The actual fluids involved will depend upon what treatment, e.g., sand consolidation, is being performed. To effect separation of one fluid from another while they are being pumped through the tubing, a solid, sacrificial wiper plug is placed in the tubing between the fluids. The sacrificial plug is formed of a material which will maintain its integrity while it is being pumped through the tubing but will decompose once it reaches the formation interval being treated. For example, preferably the wiper plug of the present invention is formed of a solid material, e.g., naphthalene plus an organic additive, which has a melting point slightly less than the temperature of the wellbore adjacent the formation interval being treated. While the sacrificial plug is in the tubing, separating the two fluids, the temperature to which said plug is exposed will be less than its melting temperature because the fluids will effectively be at surface temperature. Further the temperature in the wellbore increases with depth so the melting temperature of the sacrificial plug will not be reached until said plug reaches its destination.

As the sacrificial wiper plug reaches the formation interval, it is ejected from the lower end of the tubing onto the bridge plug where it decomposes. By the time the treatment of the formation interval is completed, the sacrificial plug will have sufficiently decomposed so that it presents no obstacle in removing the bridge plug.

The upper packer is then released and the tubing is lowered to engage the bridge plug which is next released by manipulation of the tubing. The tubing, now carrying the bridge plug at its lower end, is raised in the wellbore to the next formation interval to be treated and the entire procedure is repeated. By using sacrificial wiper plugs to separate the various fluids, the treatment operation can be repeated many times at different levels in the wellbore without ever removing the tubing from the well. The savings in both time and money is substantial.

BRIEF DESCRIPTION OF THE DRAWINGS

The actual operation and the apparent advantages of the present invention will be better understood by referring to the drawings in which:

FIG. 1 is a schematical view, partly in section, of a wellbore in which the present invention is carried out; and

FIG. 2 is a perspective view of a sacrificial wiper plug in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to FIG. 1, a portion of a wellbore 10 is illustrated. Wellbore 10 is typical in that it passes through several earth formations and is completed in accordance with well-known techniques, i.e., a casing 11 is run into wellbore 10 and is cemented therein. As illustrated, wellbore 10 is shown as penetrating two producing formations 12, 13 which are "incompetent" in that if casing 11 is perforated adjacent these formations, excessive slids, e.g., sand, will flow into wellbore 10 with the produced fluids, thereby causing substantial production and maintenance problems.

In the following description, a typical sand consolidation process is used to illustrate the present invention but it should be understood that the present invention could be used in other well treating operations which require two or more fluids to be physically separated while they are injected into a formation interval to be treated through a common tubing.

In carrying out a sand consolidation process in accordance with the present invention, the portion of wellbore 10 which lies adjacent to the first formation interval to be consolidated is isolated. This is preferably done by the packer means shown in FIG. 1. Bridge plug 20 is carried to its position at the lower end of formation 12 by conduit or tubing 21. Bridge plug 20 is then set by manipulation of tubing 21 after which it is released from the tubing. Tubing 21 is then raised to the upper end of formation 12 where packer 22, which is mounted on tubing 21, is set to isolate portion 23 of wellbore 10 which lies adjacent the formation interval to be treated, e.g., formation 12. The details of the apparatus just described form no part of the present invention and are well known in the art, e.g., see pp. 564-568 and pp. 2,358-2,359 of Composite Catalog of Oil Field Equipment and Services, 29th Revision, 1970-71, published by WORLD OIL.

Perforations 14 are next formed through casing 11 adjacent formation 12 by any well-known means in the art, e.g., a "through-tubing" perforator (not shown) to communicate portion 23 of wellbore 10 with formation 12. At this point the actual, desired treating process is carried out. In a typical sand consolidation process, several different fluids are injected into formation 12 through tubing 21. For example, a preflush may be used to clean the perforations and to remove the filter cake on the formation caused by the mud used in drilling the well. Next, an epoxy resin, which is the agent which will actually consolidate the loose sand grains in formation 12, is injected through tubing 21. The resin is followed by a curing agent which, when combined with the resin, will react to cause the resin to solidify and thereby effect the desired consolidation of formation 12. Finally, an overflush, e.g., diesel oil, is pumped

through tubing 21 to insure that all the curing agent is forced into formation 12 and in some instances to establish permeability within the formation and to speed curing of the resin. In processes such as just described, it is desirable, if not necessary, to physically separate the various fluids while they are being injected through tubing 21. For example, it should be obvious that a premature mixing of the resin and curing agent would be undesirable in this process since the resin might partially cure in the tubing and plug same.

The technique most commonly used in the presently available processes of this type involves the use of solid wiper plugs to separate the fluids while they are being pumped through tubing 21. These plugs, which are of hard rubber or the like, may be expelled from the lower end of the tubing in which case they fall onto bridge plug 20 or, as is more often the case, the solid wiper plugs may be caught in a "plug catcher" (not shown) which is located in tubing 21 below packer 22. Perforations (not shown) would be provided in the tubing above the plug catcher but below the upper packer to allow the treating fluid behind the caught plug to flow into portion 23 of wellbore 10. However, where several wiper plugs are "caught" in the tubing, these perforations become blocked and the tubing has to be pulled to remove the caught plugs before additional treating operations can be carried out.

Further, as seen in FIG. 1, if a solid wiper plug 25 is expelled out of tubing 21 onto bridge plug 20, it is likely to create problems when bridge plug 20 is to be retrieved and reset at another position within wellbore 10. This problem becomes even more acute when additional solid wiper plugs, e.g., 25a, are expelled onto bridge plug 20 as is often the case in typical treating operations where the wiper plugs are not caught.

In carrying out a well treatment operation such as the above-described sand consolidation process in accordance with the present invention, a sacrificial wiper plug 30, such as shown in FIG. 2, is used to effect physical separation between the different fluids while they are being pumped through tubing 21. Sacrificial plug 30 is comprised of a material which will maintain its integrity throughout the substantial length of tubing 21 but will sufficiently decompose upon reaching portion 23 of wellbore 10 to offer no problems in retrieving and resetting bridge plug 20. This means that source decomposition of plug 30 may occur, e.g., slight melting, in tubing 21 before plug 30 reaches its final destination but this decomposition is not enough to affect the successful function of plug 30.

Preferably, sacrificial plug 30 is comprised of eutectic compounds formed by combinations of certain organic compounds which yield a solid, hard, soap-like material, but one which has a melting temperature such that sacrificial plug 30 will decompose at elevated well temperatures, e.g., naphthalene plus an organic additive. The following table sets out eutectic compounds which can be used to form sacrificial plug 30 and illustrates how the melting temperature of the desired material can be regulated for different wellbore temperatures.

Another material which can be used for constructing sacrificial plug 30 is wax material which may be a blend of waxes which will melt at a desired temperature. For example, if the temperature adjacent formation 12 is 155°-160° F., plug 30 could be made from a material comprised of 90 percent by weight of a 138° F. melting point paraffin wax and 10 percent by weight of C₁₇

polyethylene. It can be seen that different waxes and additives can be blended to provide different materials having different melting temperatures. Other materials for forming sacrificial plug 30 could be (1) salts which are soluble in natural occurring brines if said brines are present in portion 23 of wellbore 10 at the completion of the well treatment operation, or (2) asphaltenes which are soluble in crude oil if said crude oil is present in portion 23 at the completion of the well treatment.

The form which sacrificial plug 30 may take is shown in FIG. 2, although it should be realized that the exact physical configuration of plug 30 is not critical to the success of the present invention. As illustrated, sacrificial plug 30 has a cylindrical body 31 which has rings 32 molded as an integral part thereof. In typical well treating operations, sacrificial plug 30 would be approximately one-foot long and have an outside diameter slightly smaller than the inside diameter of the tubing 21 through which it is to be pumped, e.g., the outside diameter of rings 32 might be 1.875 inches if the inside diameter of tubing 21 is 2 inches.

It can be seen that by using sacrificial plug 30 to separate two different fluids as they are pumped through tubing 21, no plug catcher is required since plug 30 can be expelled out of tubing 21 onto bridge plug 20. In the preferred case, the organic material comprising sacrificial plug 30 will have a melting temperature slightly less than the temperature existing in portion 23 of wellbore 10 so that plug 30 will begin to melt and decompose as it reaches portion 23 of wellbore 10 and will continue to do so while the well treating operation continues. Upon completion of the well treating operation, sacrificial plug or plugs 30, if more than one is used, will have decomposed sufficiently so that they offer no obstacle to the retrieval of bridge plug 20. Bridge plug 20 is then retrieved by releasing upper packer 22 and lowering tubing 21 to engage bridge plug 20. The tubing is then manipulated to release bridge plug 20 after which the entire apparatus is raised in wellbore 10 to a position adjacent the next formation interval to be treated, e.g., formation 13, and the entire well treating operation is repeated.

By using sacrificial wiper plugs of decomposable material in accordance with the present invention, there is no need to pull tubing 21 after each well treatment operation to remove caught plugs. Also, there are no solid wiper plugs present to interfere with the retrieval of bridge plug 20. This allows bridge plug 20 to be readily retrieved and the well treating operation can be repeated in wellbore 10 as many times as necessary. Since the tubing need not be pulled and rerun after each operation, a substantial saving in both time and expense is realized.

What I claim is:

1. A process for treating an earth formation interval in a penetrating wellbore comprising:
 - isolating that portion of the wellbore which lies adjacent the formation interval to be treated;
 - providing a conduit between the surface of said wellbore and said portion of said wellbore;
 - injecting a first well treating fluid into said formation interval through said conduit;
 - injecting a second well treating fluid of a different composition from said first treating fluid into said formation interval through said conduit immediately behind said one well treating fluid; and

separating said first and said second well treating fluids while they are in said conduit with a sacrificial plug comprised of material which will substantially maintain its integrity while in said conduit but will decompose once said sacrificial plug reaches said portion of said wellbore.

2. The process of claim 1 wherein:

said sacrificial plug material is a solid material which will melt at the temperature existing in said portion of said wellbore.

3. The process of claim 2 wherein:

said sacrificial plug material is comprised of solid, eutectic combination of organic compounds which will melt at the temperature existing in said portion of said wellbore.

4. The process of claim 3 wherein:

said eutectic combination of organic compounds comprises naphthalene and an organic additive which adjusts the temperature at which said eutectic combination will melt.

5. The process of claim 2 wherein:

said sacrificial plug material is comprised of a wax material which will melt at the temperature existing in said portion of said wellbore.

6. The process of claim 1 wherein:

said sacrificial plug material is a solid material which will dissolve in well fluid which is present in said portion of said wellbore.

7. A process for treating a plurality of earth formation intervals penetrated by a wellbore, said process comprising:

positioning a lower packer means adjacent the lower point of the first of said formation intervals to be treated and setting said lower packer means to close said wellbore at said lower point;

positioning an upper packer means adjacent the upper point of said first of said formation intervals to be treated and setting said upper packer means to close said wellbore at said upper point and to isolate a first portion of said wellbore between said packer means which lies adjacent said first of said formation intervals to be treated;

providing a conduit which extends from the surface of said wellbore, through said upper packer means, and into said first portion of said wellbore;

injecting one well treating fluid into said first formation interval through said conduit;

injecting another well treating fluid into said first formation interval through said conduit immediately behind said one well treating fluid;

separating said one and said another well treating fluid while they are in said conduit with a sacrificial plug comprised of material which will substantially maintain its integrity while in said conduit but will decompose when said sacrificial plug reaches said first portion of said wellbore;

releasing said upper and said lower packer means;

repositioning said lower packer means adjacent the lower point of the second of said formation intervals to be treated and setting said lower packer means to close said wellbore at said point;

repositioning said upper packer means adjacent the upper point of said second formation interval to be treated and setting said upper packer to close said wellbore at said upper point and to isolate a second portion of said wellbore between said packer

means which lies adjacent said second of said formation intervals to be treated;
providing said conduit from the surface of said wellbore, through said upper packer means, and into said second portion of said wellbore, the steps of releasing, repositioning, and resetting said packer means and of providing said conduit being carried out without removing a substantial portion of said conduit from said wellbore;
injecting one well treating fluid into said second formation through said conduit;
injecting another well treating fluid into said second formation interval through said conduit immediately behind said one well treating fluid; and
separating said one and said another well treating fluids while they are in said conduit with another sacrificial plug comprised of material which will substantially maintain its integrity while in said conduit but will decompose when said another sacrificial plug reaches said second portion of said wellbore.
8. The process of claim 7 further comprising:
repeating the above steps until all of said formation intervals have been treated.
9. The process of claim 7 wherein:
said sacrificial plug material used in said first portion is solid material which will melt at the temperature existing in said first portion of said wellbore; and
said sacrificial plug material used in said second portion is a solid material which will melt at the temperature existing in said second portion of said wellbore.
10. The process of claim 9 wherein:
said sacrificial plug material used in said first portion

is comprised of a wax material which will melt at the temperature existing in said first portion of said wellbore; and
said sacrificial plug material used in said second portion is comprised of a wax material which will melt at the temperature existing in said second portion of said wellbore.
11. The process of claim 9 wherein:
said sacrificial plug material used in said first portion is comprised of a solid, eutectic combination of organic compounds which will melt at the temperature existing in said first portion of said wellbore; and
said sacrificial plug material used in said second portion is comprised of solid, eutectic combination of organic compounds which will melt at the temperature existing in said second portion of said wellbore.
12. The process of claim 10 wherein:
said eutectic combination of organic compounds comprises naphthalene and an organic additive which adjusts the temperature at which said eutectic combination will melt.
13. The process of claim 7 wherein:
said sacrificial plug material used in said first portion is a solid material which will dissolve in well fluid which is present in said first portion of said wellbore; and
said sacrificial plug material used in said second portion is a solid material which will dissolve in well fluid which is present in said second portion of said wellbore.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,768,563 Dated October 30, 1973

Inventor(s) Elmo M. Blount

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 3, line 16, "is" should be --it--, first occurrence
line 22, "slids" should be --solids--.
Column 4, line 12, "tye" should be --type--;
line 15, "ike" should be --like--;
line 46, "source" should be --some--;
line 60, The following table was omitted:

		Melting Point (°C) at % of Compound A					
Compound A	Compound B	100%	80%	70%	60%	50%	40%
1. naphthalene (C ₁₀ H ₈)	α-naphthylamine (C ₁₀ H ₉ N)	80	69	65.5	58	54	46
2. naphthalene (C ₁₀ H ₈)	Bromocamphor	80	73.5	67.5	61	53	-
3. naphthalene (C ₁₀ H ₈)	Thymol	80	70.5	65.4	59.7	53.3	44.8
4. naphthalene	α-napthol	80	88.3	92.5	-	-	-

- Column 6, Claim 3, line 1, "caim" should be --claim--;
Claim 7, line 3, "compgising" should be
--comprising--.
Column 7, Claim 9, line 3, --a-- should be inserted before
"solid".

Signed and sealed this 25th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents