PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		(11) International Publication Number:
E21B 43/04	A1	WO 94/19577
		(43) International Publication Date: 1 September 1994 (01.09.94)

(21) International Application Number: PCT/US94/00827

(22) International Filing Date: 24 January 1994 (24.01.94)

(30) Priority Data:
023,454 26 February 1993 (26.02.93) US

(71) Applicant: MOBIL OIL CORPORATION [US/US]; 3225 Gallows Road, Fairfax, VA 22037-0001 (US).

(72) Inventors: JONES, Lloyd, Garner; 2029 Ebbtide Lane, Dallas, TX 75224 (US). YATES, Tommy, J.; 413 Kaye, Coppell, TX 75019 (US).

(74) Agents: SUNG, Tak, K. et al.; Office of Patent Counsel, Mobil Oil Corporation, 3225 Gallows Road, Fairfax, VA 22037-0001 (US).

(81) Designated States: CA, DE, GB, NO, RU.

Published
With international search report.

(54) Title: METHOD FOR INSTALLING A GRAVEL PACK COMPLETION IN A WELL

(57) Abstract

A method of completing a well which includes the installation of a gravel pack completion adjacent a formation in the well. A fluid-loss agent is flowed into the well to form a barrier to flow into and out of the formation prior to the installation of the gravel pack. A screen is then lowered into the well and is positioned adjacent the formation. A gravel slurry which includes a removal agent is flowed into the well to deposit gravel. The removal agent contacts and dissolves or disintegrates the flow barrier to thereby open flow to the formation during the placement of the gravel.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**GB**	United Kingdom	**MR**	Mauritania
AU	Australia	**GE**	Georgia	**MW**	Malawi
BB	Barbados	**GN**	Guinea	**NE**	Niger
BE	Belgium	**GR**	Greece	**NL**	Netherlands
BF	Burkina Faso	**HU**	Hungary	**NO**	Norway
BG	Bulgaria	**IE**	Ireland	**NZ**	New Zealand
BJ	Benin	**IT**	Italy	**PL**	Poland
BR	Brazil	**JP**	Japan	**PT**	Portugal
BY	Belarus	**KE**	Kenya	**RO**	Romania
CA	Canada	**KG**	Kyrgystan	**RU**	Russian Federation
CF	Central African Republic	**KP**	Democratic People's Republic of Korea	**SD**	Sudan
CG	Congo			**SE**	Sweden
CH	Switzerland	**KR**	Republic of Korea	**SI**	Slovenia
CI	Côte d'Ivoire	**KZ**	Kazakhstan	**SK**	Slovakia
CM	Cameroon	**LI**	Liechtenstein	**SN**	Senegal
CN	China	**LK**	Sri Lanka	**TD**	Chad
CS	Czechoslovakia	**LU**	Luxembourg	**TG**	Togo
CZ	Czech Republic	**LV**	Latvia	**TJ**	Tajikistan
DE	Germany	**MC**	Monaco	**TT**	Trinidad and Tobago
DK	Denmark	**MD**	Republic of Moldova	**UA**	Ukraine
ES	Spain	**MG**	Madagascar	**US**	United States of America
FI	Finland	**ML**	Mali	**UZ**	Uzbekistan
FR	France	**MN**	Mongolia	**VN**	Viet Nam
GA	Gabon				

"METHOD FOR INSTALLING A GRAVEL PACK COMPLETION IN A WELL"

The present invention relates a method for installing a gravel pack completion adjacent a formation in a well.

In producing hydrocarbons or the like from loosely or unconsolidated and/or fractured subterranean formations, it is not uncommon for large volumes of particulate material (e.g. sand) to flow in the formations along with the produced fluids. As is well known in the art, these particulates routinely cause a variety of problems and must be controlled in order for production to be economical. Probably the most popular technique used for controlling the production of particulates (e.g. sand) from a well is one which is commonly known as "gravel packing".

In a typical gravel pack completion, a screen is lowered into the wellbore on a workstring and is positioned adjacent the subterranean formation is to be completed, e.g. a producing formation. Particulate material, collectively referred to as gravel, and a carrier liquid is then pumped as a slurry down the workstring where it exits through a "cross-over" or the like above the screen and flows downward between the screen and the well casing or open hole, as the case may be. The carrier liquid in the slurry normally flows into the formation and/or the openings in the screen which, in turn, are sized to prevent the flow of gravel therethrough. This results in the gravel being deposited or "screened out" in the annulus around the screen where it collects to form the gravel pack. The gravel, in turn, is sized so that it forms a permeable mass which allows flow of the produced fluids therethrough and into the screen while blocking the flow of any particulates produced with the formation fluids.

One problem which exists in gravel packing a well arises from the use of typical "well completion fluids" in the well while installing a gravel pack therein. For example, the "drilling mud", which is used in drilling a well may be replaced with a high-density, well-completion fluid, e.g. "heavy brine"

in order to control high pressure zones in the well while the well is cased and perforated. Further, the completion fluids do not form a "filter cake" as do most drilling muds which could block the perforations once they were formed in the well casing and which would be extremely difficult to remove once the gravel pack was in place.

While high-density, well-completion fluids (e.g. zinc bromide brines) are routinely used in most wells, they are very expensive and must be substantially recovered after they have served their purpose in order for such fluids to be used economically. Unfortunately, however, due to the density or "weight" of these completion fluids, there is always a real danger that substantial volumes, if not all, of these fluids may be "lost" into a formation within the wellbore during the completion of a well. That is, the pressure due to the head of completion fluid in the wellbore, being greater than the pressure in the formation, may cause the completion fluid to flow from the wellbore into the formation where it becomes "lost" and can not be recovered.

To prevent the loss of the expensive completion fluids into a formation, it is common in the well completion art to use "fluid-loss" agents in conjunction with the completion fluid. As a "fluid-loss" agent, e.g. benzoic acid flakes, flows through the casing perforations into a formation, the agent forms a barrier which blocks further flow of fluid, i.e. the expensive completion fluid, therethrough. However, since the formation must eventually be produced back through the same perforations, the barriers formed by the fluid-loss agent obviously have to be removed from the perforations after the well has been gravel packed and is ready to be put on production.

In known prior well completions, when a gravel pack is installed in a well wherein the perforations are blocked by a fluid-loss agent, the perforations will remain blocked while the gravel is being placed. Accordingly, the carrier fluid from the gravel slurry can only flow through the openings in the screen. Since the slurry can not flow through the blocked perforations, no gravel will be deposited in the perforations themselves,

thereby producing a less than desired gravel pack.

Once the gravel is in place, a removal agent such as gelled diesel is then pumped down the wellbore and into the gravel pack to contact and react with the fluid-loss agent in the perforations to reopen the perforations to flow. Unfortunately, it is believed that the removal agent will contact and remove the fluid-loss barrier in the uppermost perforations before it has had a chance to reach all of the perforations in the casing. Once the flow barriers are removed from the upper perforations, the removal agent will merely take the path of least resistance and flow into the formation through the open, upper perforations. Accordingly, the lower perforations may remain blocked during production.

The "removal agent" is a material which reacts with the fluid-loss agent to dissolve or disintegrate the flow barriers in the perforations. By incorporating the removal agent directly into the gravel slurry, the gravel in the slurry acts as an excellent diverter to direct the removal agent into contact with the fluid-loss agent in all of the perforations to thereby open substantially all of the perforations to flow. Once the perforations are open, the gravel slurry can now flow therethrough and deposit gravel therein, thereby "packing" the perforations and greatly improving the efficiency of the gravel pack.

In completing a well, it is often necessary to use a high-density, well-completion fluid to "balance" or otherwise control high-pressure zones in the well. In order to be able to use such expensive fluids, e.g. zinc bromide brines, the fluid, itself, must be recoverable for reuse. Unfortunately, however, the pressure in the wellbore due to the head of the completion fluid may be substantially greater than the formation pressure which may result in the fluid flowing from the wellbore into the formation where substantial volumes are "lost" to the formations.

To prevent this from occurring, it is common and well known in the art to use "fluid loss" agents in conjunction with such expensive well-completion fluids to block flow into the

formation and thereby prevent the loss of the well-completion fluid. Such agents are well known (e.g. benzoic acid flakes, cross-linked hydroxethyl cellulose (HEC); powdered calcium carbonate, etc.) and all are commercially-available for this purpose. As will be understood in the art, the fluid-loss agent forms a barrier as it flows through casing perforations or the like which then blocks flow of the expensive well-completion fluid therethrough, thereby preventing the loss of this fluid into the formation.

Using a fluid-loss agent in completing a well does, however, creates certain disadvantages when a gravel pack is to be installed in the well. That is, in installing a typical gravel pack completion in a well in which a fluid-loss agent has been used in conjunction with a well completion fluid, it is common to leave many of the perforations blocked until after the gravel pack is in place. Accordingly, substantially no gravel will be deposited in the perforations, since the flow-blocking barriers formed in the perforations by the fluid-loss agent will prevent any substantial amount of the gravel slurry from flowing therethrough. Accordingly, the perforations, themselves, are not "gravel packed" which adversely affects the efficiency of the overall gravel pack and which is likely to lead to problems later in the production of the well.

As will be understood, after the gravel pack is in place, it is then necessary to "open" the perforations in order for the desired formation fluids, e.g. oil, to flow into the wellbore. A removal agent is then flowed down the wellbore and through the gravel. "Removal agent", as used herein, refers to a material which reacts with a particular fluid-loss agent upon contact therewith to dissolve or disintegrate the flow barrier formed by the fluid-loss agent to displace or remove it the flow barriers from the perforations. Examples of typical removal agents and the respective fluid-loss agents with which each may be used are: (a) a removal agent comprised of gelled acid such as hydrochloric acid which may be sued to react with fluid-loss agents such as powdered calcium carbonate or crosslinked HEC; (b) a removal agent comprised of gelled diesel or other light

hydrocarbon (e.g. produced condensate) which may be used to react with a fluid-loss agent such as benzoic acid flakes; etc. As will be understood in the well completion art, these fluid-loss agents and their respective removal agents are well known in this art.

When the removal agent is flowed into the compacted column of gravel which has previously been deposited around the screen, it does not flow evenly through the gravel. Instead, it contacts and reacts with the fluid-loss agent in the upper perforations thereby opening those perforations to flow. Once the upper perforations are opened, the removal agent takes the path of least resistance and flows into the formation through the open perforations. Accordingly, the removal agent does not readily flow through the gravel to contact the lower perforations which remain closed to flow thereby adversely affecting production from the well.

According to one aspect of the present invention there is provided a method of installing a gravel pack completion adjacent a formation in a well, said method comprising:

(a) flowing a fluid-loss agent into contact with said formation to from a barrier to flow into said formation;

(b) positioning a screen in said well adjacent said formation; and

(c) flowing a gravel slurry into said well and around said screen to deposit gravel around said screen, said gravel slurry including a removal agent which reacts with said fluid-loss agent to remove said barrier to flow into and from said formation while said gravel is being placed around said screen.

In one embodiment said fluid-loss agent comprises crosslinked HEC (hydroxyethyl cellulose), and said removal agent comprises a gelled acid.

In another embodiment said fluid-loss agent comprises calcium carbonate, and said removal agent comprises a gelled acid.

The gelled acid comprises preferably comprises a gelled,

dilute hydrochloric acid.

In a further embodiment said fluid-loss agent comprises benzoic acid flakes, and said removal agent comprises gelled diesel.

Preferably the well is a cased well having perforations therein, said fluid-loss agent is flowed through said perforations into contact with said formation, and said removal agent is adapted to react with fluid-loss agent while said gravel is being deposited to thereby remove said barrier and open said perforations to flow therethrough.

According to another aspect of the invention there is provided a method of completing a well which includes the installation of a gravel pack in accordance with the method of any of claims 1 to 7.

As will be understood by those skilled in the art, "screen" as used herein refers to any type of structure, e.g. a screen, a prepacked screen, slotted or perforated liner, etc. which is routinely used in the gravel packing of a well.

By incorporating the removal agent directly into the gravel slurry, the gravel, itself, acts as an excellent diverter for the removal agent during the placement of the gravel around the screen. This allows the removal agent to contact and remove the fluid-loss agent from all of the perforations, not just the upper perforations as is the case in the prior art. Further, since all of the perforations are opened as the removal agent contacts the fluid-loss agent therein, gravel slurry can flow through the respective perforation while the gravel is being placed around the screen. As the carrier fluid is lost into the formation, the gravel from the slurry is deposited in the perforations, themselves, which greatly improves the efficiency of the gravel pack being installed.

Claims

1. A method of installing a gravel pack completion adjacent a formation in a well, said method comprising:

(a) flowing a fluid-loss agent into contact with said formation to from a barrier to flow into said formation;

(b) positioning a screen in said well adjacent said formation; and

(c) flowing a gravel slurry into said well and around said screen to deposit gravel around said screen, said gravel slurry including a removal agent which reacts with said fluid-loss agent to remove said barrier to flow into and from said formation while said gravel is being placed around said screen.

2. A method according to claim 1, wherein said fluid-loss agent comprises crosslinked HEC, and said removal agent comprises a gelled acid.

3. A method according to claim 1, wherein said fluid-loss agent comprises calcium carbonate, and said removal agent comprises a gelled acid.

4. A method according to claim 2 or 3, wherein said gelled acid comprises a gelled, dilute hydrochloric acid.

5. A method of claim 1 wherein said fluid-loss agent comprises benzoic acid flakes, and said removal agent comprises gelled diesel.

6. A method according to any preceding claim, wherein the well is a cased well having perforations therein, said fluid-loss agent is flowed through said perforations into contact with said formation, and said removal agent is adapted to react with fluid-loss agent while said gravel is being deposited to thereby remove said barrier and open said perforations to flow

therethrough.

7. A method of completing a well which includes the installation of a gravel pack in accordance with the method of any of claims 1 to 7.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/00827

CLASSIFICATION OF SUBJECT MATTER

.PC(5) :E21B 43/04
US CL :166/278, 300

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. : 166/276, 278, 300

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y,P	US, A 5,222,558 (Montgomery et al.) 29 June 1993, col. 4, line 60 - col. 5, line 9; col. 6, lines 9-11	1
Y,P	US, A, 5,191,931 (Himes et al .) 09 March 1993, col. 5, lines 15-23.	1
A, P	US, A, 5,269,375 (Schroeder, Jr.) 14 December 1993	1,4,5
A	US, A, 4,664,191(Jennings, Jr.) 12 May 1987	1,4
A	US, A, 5,072,791 (Whitebay) 17 December 1991	1,4

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

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 23 March 1994	Date of mailing of the international search report 11 APR 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305 - 3230	Authorized officer GEORGE SUCHFIELD Telephone No. (703) 308-2168

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/00827

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: 7 and 8
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.