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[54] SEALER BALL CATCHER AND METHOD OF USE THEREOF

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[56] References Cited
UNITED STATES PATENTS
2,349,062 5/1944 Uren ........................................... 166/278
2,603,293 7/1952 Lynes ........................................ 166/169 X
2,942,664 6/1960 Burns ........................................ 166/51
3,011,548 12/1961 Holt ........................................ 166/284
3,028,914 4/1962 Flickinger ................................ 166/284
3,421,586 1/1969 Solum ...................................... 166/51

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[57] ABSTRACT

A tool for use with perforation sealer balls utilizes a hollow outer mandrel, a perforated liner, and an elastomeric ball guide and casing seal to channel perforation balls from the casing into a hollow retention mandrel in the lower packer.

11 Claims, 5 Drawing Figures
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SEALER BALL CATCHER AND METHOD OF USE THEREOF

BACKGROUND OF THE INVENTION

During the treating of oil producing formations to increase productivity, such treatment including hydraulic fracturing and acidizing, hydraulic treating fluid is pumped into the wellbore to exit through perforations in the casing and cement and into the formation.

To insure that all perforations take fluid and some do not remain untreated due to blockage of sediment, perforation seal balls are introduced into the treating fluid during intermediate phases of the pumping. The seal balls are designed to seat in the perforations taking fluid thereby exposing plugged or low flowing perforations to the maximum flow pressure. Usually a large number of seal balls, in the range of 75–100 or more, are placed in the wellbore.

When a formation in a multi-formation well is treated, it is usually isolated from the other formations by a retrievable bridge plug (RBP) below the formation and a packer above the formation. This apparatus serves to satisfactorily treat the first formation being treated. When it becomes desirable to move up or down to the next formation in the well, the upper packer is released and then the tubing string is lowered to engage and release the RBP. This is after the fluid pressure on the formation has ceased which allows the perf balls to drop down through the fluid in the casing to lodge in, on, and around the RBP.

These balls make engagement and release of the RBP difficult to achieve. While the RBP and the tubing string are being moved to the next formation in the well, the balls work their way into the RBP mechanism and around the outer packer elements to prevent a successful resetting of the RBP at the next formation. Most of the perf balls become torn up in the RBP mechanism and form sediment to jam the mechanism. Some of the balls bypass the RBP and drop to the next lower tool or to the bottom of the borehole. Some of the balls are caught between the RBP and the casing and further prevent a successful seal therebetween at the next formation.

Thus, frequently the string must be pulled from the well after each treatment, necessitating a lengthy and expensive treatment in the multi-formation well due to the high cost of rig-time, man-hours, and lost production while the well is down.

One method of solving this problem in the past has been to rig a catcher screen or "basket" on the upper end of the RBP to catch the released perf balls. This worked fine but had a narrowly limited use since it could only successfully trap a small number of the perf balls. In the multiple formation wells having as many as four or more formations, as many as 700–800 perf balls might be used in treating the entire well. The catcher basket was limited to holding at most about 50 to 75 balls. Any number greater than this stacks up above the basket and may become wedged between the basket and the casing or may bridge above and tightly wedge the entire RBP tool in the casing necessitating a milling job to remove the tool.

Furthermore, with a large number of perf balls it was necessary to stack the balls so high above the basket to retain them all that the latching mechanism on the RBP, by which the tool string is lowered onto it to release it, was covered up by perf balls and the RBP could not be released and had to be milled out.

Thus, it is clear that the basket has only narrowly limited use and is restricted to wells requiring a small number of perf seal balls.

The present invention solves the above problem by providing a tool to collect the perf balls, separate them from the fluid without plugging or bridging, and transfer them to a retention area in the RBP. This insures that the balls will not interfere with operation of the RBP on subsequent treatments and has the incidental additional benefit of preserving the perf balls which means additional economic benefits to the well operator.

BRIEF DESCRIPTION OF THE DRAWINGS.

FIGS. 1a through 1d are schematic illustrations of the operation of this invention in a tool string in a multi-formation well;

FIG. 2 is a cross sectional illustration of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS.

FIGS. 1a through 1d are sequential schematic illustrations of the present invention located in a workstring. In FIG. 1a the perf ball diverting tool 1 is shown interconnected in the tubing string 4 between an upper packer 2 and a lower packer or retrievable bridge plug 3. The upper packer 2 may be of the type sold by Guiberson Division of Dresser Industries, Inc., 1000 Forest Avenue, Dallas, Texas, and designated a Uni-Packer V well packer.

The lower packer 3 may be of the type having a hollow mandrel extending therethrough and closed off at the lower end, such as a Uni-Packer VI well packer, also sold by Guiberson Division of Dresser Industries, Inc.

The workstring containing the two packers and the diverting tool is lowered into the wellbore until the two packers straddle the lower most perforations 5 or the perforations desired for treatment. Preferably the diverting tool 1 is also located below the perforations 5.

After the workstring has been located in the wellbore, the lower packer is set by mechanical manipulations of the workstring and then the workstring is further manipulated to disengage the on-off tool 6 from the J-slot arrangement at the top of the diverting tool 1. The workstring is then raised to place the upper packer 2 above the perforations and the upper packer is then set.

The tools are then in the orientation of FIG. 1b.

At this point, the subject zone, communicating through perforations 5, is isolated from other zones in the wellbore and the treating fluid can be pumped into the formation. At some point in time during the pumping, the perf seal ball 7 are introduced into the pumped fluid to provide the selective perforation sealing previously described. The treating fluid and perf balls are normally placed into the tubing 4 and pass out through the bottom of the on-off tool 6.

FIG. 1c illustrates what happens after pressure is relieved from the treating fluid. The perf balls which have been held against the casing perforations by differential pressure now drop downward in response to gravitational forces to the elastomeric cup 8 facing upward and fixedly attached to the diverting tool 1.
The elastomeric cup 8 tends to channel the balls into one or more elongated openings 10 in the wall of the hollow mandrel 9 of the diverting tool. The balls fall downward into a perforated liner located concentrically in the hollow mandrel 9. The fluid is allowed to exit through the perforations in the liner and out a second set of elongated slots 11 in the wall of the hollow mandrel 9 below cup 8. The balls are prevented from moving through slots 11 and, due to the force of gravity thereon, drift downward through the hollow mandrel of lower packer 3 to collect in the hollow retainer mandrel 12 attached to the lower end of the packer mandrel.

After the treatment has been completed, the upper packer 2 is unseated and the string is lowered to engage the on-off tool 6 on the J-slot arrangement of the diverting tool. Then the string is manipulated to unseat the lower packer and the string can be moved upward to another formation to be treated, as shown in FIG. 1A.

The cup 8 provides an efficient seal against the casing wall and thereby channels fluid flow through the diverting tool as the workstring moves upward. This insures that all of the perf balls are moved into the tool and dropped into the retention mandrel 12 through the lower packer 3.

Referring now to Fig. 2, a more detailed description of the diverting tool 1 can be given. The tool comprises a hollow tubular upper slotted mandrel 9 to which is threadably attached a tubular J-slot mandrel 14 having a J-slot 15 formed externally thereon. A lower slotted tubular mandrel 16 is attached to the upper mandrel 9 by a threaded connector collar 17.

An elastomeric seal cup 8 is held abuttingly on mandrel 9 against an integral flange 20 formed on mandrel 9. An annular flange 19 formed on the upper end of connector collar 17 serves to hold sealing cup 8 against flange 18 when collar 17 is threaded fully onto mandrel 9.

A tubular perforated liner 13 is securedly held in inside mandrels 9 and 16 by annular rings 20 and 21. Upper ring 20 seals off the annular area between the mandrel 9 and the liner 13 thereby forcing all fluid flow through the seal cup 8 to be diverted into the liner. This assures that all the perf balls are channeled into the liner which is desirable.

The perforated liner 13 is designed so that the inner diameter is less than twice the diameter of the perf balls thereby allowing only a single-file flow of the balls therethrough. This prevents bridging or jamming of the balls in the liner. Also the perforations are spaced in the liner at short enough intervals to prevent sealing of the perfs by the balls passing through the liner.

The above mentioned Guiberson Uni-Packer VI well packer is particularly useful below the diverting tool 1 because of its hollow mandrel type of construction. This allows passage of the perf balls through the packer to a capped retainer mandrel 12 extending from the bottom of the packer mandrel without the passage of the balls in any way interfering with the operation of the packer and indefinite number of times. The length of the retention chamber 12 may be extended to hold any number of perf balls depending on the number of formations treated and the number of perforations per formation.

The perf balls from each formation are added to those retained from previous treatments and are recovered intact when the well service is completed and the workstring is removed from the well. In some wells this may result in saving up to 700 perf balls which represents a substantial economic savings since these balls normally cost the well operator about 75 cents a piece.

This invention thus saves the operator the expense of pulling the workstring after each formation is treated, or alternately, reverse circulating as many perf balls as possible out of the well after each treatment. It also saves the operator the cost of lost perf balls since all the perf balls are safely retained in the workstring to be later recovered intact.

Although a specific perfed embodiment of the present invention has been described in the detailed description above, the description is not intended to limit the invention to the particular forms or embodiments disclosed herein, since they are to be recognized as illustrative rather than restrictive and it will be obvious to those skilled in the art that the invention is not so limited. For example, whereas a J-slot latching arrangement is shown, it is possible to use an alternative latching mechanism such as threads or locking dogs. Also it is clear that any type sealing means other than the elastomeric cup can be used to form a seal between the diverting tool and the casing. It is also possible to use several different types of packers or retrievable bridge plugs in the lower packer position than those illustrated or described. Furthermore, other types of packers could be substituted for the upper packer in the above described operation. The invention is declared to cover all changes and modifications of the specific example of the invention herein disclosed for purposes of illustration, which do not constitute departures from the spirit and scope of the invention.

The embodiments of the invention in which an exclusive property of privilege is claimed are defined as follows:

1. Oil well servicing apparatus for diverting perforation sealer balls into a collection area, said apparatus comprising:

   upper mandrel means having a bore passage therethrough and flow port means through the wall thereof;

   lower tubular mandrel means connected to the lower end of said upper mandrel means and having flow port means through the wall thereof;

   perforated tubular liner means located concentrically in said upper and lower mandrel means with the upper end of said liner means being open and communicating with said upper mandrel flow port means, and the perforations in said liner means communicating with said lower mandrel port means; and,

   annular seal means on said apparatus, located below said upper port means, and adapted to provide an annular seal between said apparatus and the oil well casing in which it is located, said seal means further adapted to channel sealer balls into said upper port means.

2. The well servicing apparatus of claim 1 wherein said perforated liner means further comprises an extended tubular member having a plurality of perforations through the wall thereof, said perforations being substantially smaller than perforation sealer balls used in the oil well being serviced, and said tubular member being a cylindrical tube having an inner diameter of less than twice the diameter of the perforation sealer balls with which it is used.
3. The apparatus of claim 2 further comprising annular seal means between said perforated liner means and said upper mandrel means, and annular attachment means between said perforated liner means and said lower mandrel means.

4. The apparatus of claim 3 further comprising releasable attachment means near the top of said upper mandrel means adapted to receive a latching tool on a workstring and to be engaged with and disengaged from the latching tool.

5. Oil well servicing apparatus for use with perforation sealing balls in treating oil wells having perforated casing, a tubing string within the casing, and a retrievable packer having a bore passage therethrough in communication with the tubing string, said apparatus comprising:

- elongated tubular body means adapted to be interconnected in the tubing string above the packer;
- means for diverting fluid and sealer balls into the inner bore passage of said body means;
- means for separating fluid from sealer balls and returning the fluid to the external annulus area around said body means; and,
- means for channeling the perforation sealer balls through the bore passage of a retrievable packer located below said apparatus.

6. A method of treating an oil producing formation through a wellbore penetrating the formation, said wellbore communicating with said formation by means of perforations in the well casing and cement, said method comprising:

- isolating the formation by means of expandable packing means above and below said formation;
- injecting treating fluid under pressure through a string of tubing and into the isolated formation;
- simultaneously injecting sealer balls with said injected fluid, said balls sized to seal the perforations;
- releasing the fluid pressure;
- diverting the sealer balls into the inner bore of the tubing string; and
- collecting the sealer balls in a chamber at the lower end of the tubing string.

7. A method of treating a plurality of oil producing formations in a single wellbore without pulling the workstring from the bore or reverse circulating perforation sealer balls out of the well, said method comprising:

- lowering into the wellbore a workstring of tubing having a plurality of packers thereon;
- placing the workstring so that the first formation to be treated is between two of the packers;
- setting the packers in the casing thereby sealing the workstring in the casing above and below the formation to be treated;
- injecting treating fluid into the formation through perforations in the casing;
- simultaneously injecting sealer balls into the treating fluid and down the workstring into the casing perforations;
- holding fluid pressure on the formation until the treatment is completed;
- releasing fluid pressure on the formation;
- diverting the sealer balls through the packer below the formation being treated;
- retaining the sealer balls in a hollow receptacle in the workstring;
- unsetting the packers;
- moving the workstring in the wellbore to isolate another formation to be treated; and
- repeating the above steps for each formation in the wellbore to be treated.

8. Apparatus for use in a tubing string for treating a multi-formation wellbore having a plurality of producing formations communicating with the wellbore through perforations in the casing, said apparatus comprising:

- upper packer means on the tubing string for sealing the annulus between the tubing string and the casing;
- lower packer means on the tubing string and located a spaced distance below said upper packer means;
- diverting means on the tubing string between said upper and lower packer means for diverting fluid flow into the tubing string inner bore;
- separating means in the tubing string for separating solid particles from the fluid flow and returning fluid to the annulus; and
- hollow retaining means in the tubing string for receiving and retaining solid particles in the fluid.

9. The apparatus of claim 8 wherein said diverting means comprises resilient cup means on the tubing string arranged to engage the casing wall; and, upper port means through the wall of the tubing string immediately above said cup means.

10. The apparatus of claim 9 wherein said separating means comprises perforated inner liner means sealingly engaged in the tubing string immediately below said upper port means; and, lower port means through the tubing wall below said cup means communicating said liner means with the casing inner annulus.

11. The apparatus of claim 10 wherein said lower packer means contains an inner bore passage passing therethrough, and said retaining means comprises a hollow retainer mandrel attached to said lower packer means, said retainer mandrel having a bore passage closed off at its lower end, and communicating with said lower packer means inner bore passage at its upper end.

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