DUAL SLEEVE MULTIPLE STAGE CEMENTER AND ITS METHOD OF USE IN CEMENTING OIL AND GAS WELL CASING

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References Cited

UNITED STATES PATENTS

This invention relates to a cementing tool used in oil and gas well multiple stage cementing operations, and more particularly to a cementing tool having an elongated case containing a plurality of ports, and two sliding sleeves within the case. The two sleeves, positioned in tandem relation one with the other, provide fluid tight seals between the ports and the interior of the cementing tool.

4 Claims, 3 Drawing Figures
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CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of an original application of the same title, Ser. No., 139,095, by O. L. Morrissett and Eugene E. Baker, filed Apr. 30, 1971, now abandoned.

BACKGROUND OF THE INVENTION

In order to cement a continuous, unbroken string of casing into a well bore in two cementing stages; i.e., placing a second quantity of cement slurry into the annular space above a previously placed first quantity, a multiple stage cementing tool which contains a number of ports thereon, is positioned in the casing string. The first quantity of cement slurry is pumped out into the annular space through the bottom of the casing string and the second quantity is pumped out into the annular space through the ports of the cementing tool. To insure that only the second quantity of cement slurry goes through the ports, sliding sleeves within the cementing tool keep the ports closed and sealed except during the time said second quantity of cement slurry is being pumped therethrough. These sliding sleeves must be fail-proof under all kinds and types of operating conditions and must provide a positive fluid tight seal.

The present invention provides a dual sleeve multiple stage cementing tool which comprises an elongated case having a plurality of ports therein, a first sleeve movably positioned in wall to wall engagement within said case and adapted to be shifted from closing said ports, and a second sleeve movably positioned in wall to wall engagement within said case, said second sleeve adapted to close said ports after shifting of said first sleeve therefrom.

BRIEF DESCRIPTION OF THE DRAWINGS

A dual sleeve multiple stage cementing tool for use in cementing casing in oil and gas wells constructed in accordance with a preferred embodiment of the invention is illustrated in the accompanying drawings in which:

FIG. 1 is a cross sectional view of the preferred embodiment of the invention; and

FIGS. 2 and 3 are cross sectional, operational views of the embodiment shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing and to FIG. 1 in particular, shown therein and generally designated by the reference numeral 10 is a dual sleeve multiple stage cementing tool constructed in accordance with the preferred embodiment of the invention. Cementing tool 10 includes case 12 whose upper end 14 and lower end 16 are attached to upper and lower casing connectors 18 and 20 respectively via companion threads 22 and 24 respectively. Casing connectors 18 and 20 are in turn attached to casing 26 via companion threads 28. A passageway 29 extends continuously through casing 26, cementing tool 10 and casing connectors 18 and 20.

Interior wall 30 of case 12 is smooth except for recesses 32 and 34 located near upper end 14 of case 12, a plurality of ports 36 which penetrate through case 12, a recess 38 on interior wall 30 surrounding ports 36, and recesses 39 and 40 near lower end 16 of case 12.

Recess 32 provides a housing for shear pin retaining ring 42. Retaining ring 42 contains a plurality of shear pins, collectively numbered 44, spaced apart equally around the ring and projecting inwardly into corresponding apertures, collectively numbered 46 positioned in the upper end 48 of upper sleeve 50.

Upper sleeve 50 is held within case 12 by said shear pins 44 as shown in FIG. 1. The outer wall 52 of sleeve 50 contains a pair of resilient, upper seal rings 54 which are housed in aforementioned recess 34 to equalize pressure between the two sets of seal rings. A second pair of resilient lower seal rings 56 are positioned near lower end 58 of upper sleeve 50. Two expandable steel lock rings 60 are positioned on outer wall 52 between seal rings 54 and 56.

Inner wall 64 of upper sleeve 50 is threaded toward lower end 58 to receive an elongated seat 66 which contains beveled surface 66a.

A lower sleeve 70, positioned immediately below upper sleeve 50, has upper end 72 and lower end 74. Outer wall 76 of sleeve 70 contains upper seal ring 78 adjacent to upper end 72 and lower seal ring 80 about midway between upper end 72 and lower end 74. The two seal rings, 78 and 80, provide a fluid tight seal between passageway 29 and ports 36 so long as lower sleeve 70 is positioned as shown in FIG. 1. An expandable lock ring 82, located below seal ring 80 on outer wall 76, will be discussed further below. Adjacent to lower end 74 is a flattened; shear ring 84 projecting into aforementioned recess 39 in interior wall 30 of case 12; lower sleeve 70 is retained in the position shown in FIG. 1 by this arrangement.

The inside wall 85 of lower sleeve 70 is threaded to receive an elongated seat 86 which contains an inwardly and downwardly sloping surface 86a which will be discussed below.

OPERATION OF THE EMBODIMENT OF FIG. 1

In describing the preferred embodiment of the present invention, reference is now made to FIG. 2 which illustrates cementing tool 10, connected to casing 26, emplaced in well bore 100. A first quantity of cement slurry 102 had been pumped down passageway 29 from the surface of well bore 100 (not shown) and into annular space 104 via the bottom of casing 26 (not shown). For purposes of this illustration the volume of slurry 102 was such as to fill the annular space 104 up to point 106 slightly below cementing tool 10.

Immediately behind slurry 102 is a calculated volume of fluid 108 which fills passageway 29 from the bottom of the well up to cementing tool 10. Following fluid 108 down passageway 29 is an opening plug 110 which contains an inwardly and downwardly sloping surface 110a. Plug 110 is described in U.S. patent application, Ser. No. 136,928 by Morrissett et al., entitled "An Oil Well Cementing Plug." As plug 110 drops into seat 86 of lower sleeve 70, surface 110a catches on surface 86a of seat 86 so that further independent downward movement of plug 110 is arrested. Also, the mating surfaces 86a and 110a provide a fluid tight seal between
the portion of passageway 29 above plug 110 from that below. A second volume of fluid 114 is pumped down passageway 29 following plug 110. This fluid presses down on lower sleeve 70 and plug 110 until ring 84 (FIG. 1) shears. Sleeve 70 and plug 110 then move downwardly until lower end 74 of sleeve 70 strikes casing connector 20, halting further downwardly movement.

After sleeve 70 has moved down to the position shown in FIG. 2, upwardly movement can occur but the amount of travel is limited by expandable lock ring 82 on sleeve 70. As the sleeve moves upward, ring 82 would expand into walls defining recess 40 and catch on the downwardly facing shoulder defined by the recess. Note that recess 40 does not hamper downward movement of sleeve 70 since the lower shoulder defined by the recess is beveled inwardly and downwardly so as to compress ring 82 back into its recess on sleeve 70.

The downwardly movement of sleeve 70 and plug 110 described above results in the opening of ports 36 to passageway 29. Fluid 114 and the second quantity of cement slurry 116 forces to plug 112 thereby shearing off from passageway 29 via ports 36 and into annular space 118 which extends upwardly from the top of the first quantity of cement slurry 112 to the surface of the well.

A closing plug 122, having beveled surface 122a thereon, follows behind cement slurry 116. A third volume of fluid, designated at 124 and immediately following plug 122, is pumped down passageway 29 from the surface to force plug 122 downwardly. In turn plug 122, having a plurality of resilient wiper blades 123 in contact with the walls defining passageway 29, drives cement slurry 116 downwardly, out through ports 36, and into annular space 118. This event continues until ports 36 are closed as will now be described with reference to FIG. 3.

In FIGS. 2 and 3, closing plug 122 passes through casing bore 29 and lands in upper sleeve 50 with face 122a of plug 122 abutting face 66c of seat 66. Mating of these two surfaces results in a fluid tight seal across the inner diameter of bore 29. Continued pressure on fluid 124 applies force to plug 122 thereby shearing out pins 44 and causing downward movement of sleeve 50 until it contacts rod 111 which passes through the axial center of plug 110 in sealing engagement therewith and which rod is held in place in plug 110 by shear means 113.

Continued fluidic pressure applied to fluid 124 causes further downward movement of sleeve 50 pushing rod 111 downward, shearing means 113, and allowing rod 111 to drop through the center of plug 110 thereby relieving entrapped fluid pressure between plugs 110 and 122.

Downward movement of plug 122 and sleeve 50 is completed when lower end 58 of sleeve 50 abuts lower sleeve 70 thereby limiting further downward movement. This results in the components being positioned as shown in FIG. 3, with lower seal rings 56 below and upper seal rings 54 above ports 36 so that a fluid tight seal is provided between passageway 29 and ports 26. Double lock rings 60 are positioned in previously mentioned recess 38 so that upward movement of upper sleeve 50 is prevented. Note that as with recess 40, the lower shoulder defined by recess 38 is beveled so as not to prevent downward movement of sleeve 50.

At the time that ports 36 have been reclosed as described above, the second quantity of cement slurry 116 has been placed into annular space 118 from the top of the first quantity of cement 102 up to a height sufficient to complete the cementing of casing 26 into well bore 100. After the cement slurry has set, plugs 110 and 122, and seats 66 and 86 in sleeves 50 and 70 respectively, are drilled out so that passageway 29 is once again open throughout casing 26. Note that one of the features of the present invention is that the inner diameters of sleeves 50 and 70 (after seats 66 and 86 have been drilled out) are the same as the inner diameter of casing 26. Thus, the presence of cementing tool 10 in the string of casing 26 will not hamper passage of oil well tools such as perforating guns, packers, tubing, pumps and so forth through passageway 29 after the cementing operations have been fully completed.

Another feature of the present invention is the use of large seal rings 54 and 56 on upper sleeve 50. Their use allows a greater clearance between sleeve 50 and interior wall 30 of case 12. The greater clearance will lessen or eliminate the effect of severe tensile and bending loads which may be imposed on cementing tool 10 if it is placed in a well which is extremely slanted from the vertical.

Yet another feature of this invention is the placing of the shear pin retaining ring 42 and shear ring 84 in recesses in the interior wall 30 of case 12. By so doing, holes through case 12, which would otherwise be necessary to hold shear pins, are avoided along with the difficulty generally encountered in preventing fluids from leaking therethrough.

Case 12 and sleeves 50 and 70 are made from steel. Seats 66 and 86 are made from aluminum, a material easily drillable. The several seal rings, such as 54 and 56, are made from resilient material such as rubber. Of course other materials may be used but those mentioned above have been found to give excellent results.

The present invention has been described in a cementing operation wherein one cementing tool 10 was employed and wherein cement slurry 102 filled the annular space up to cementing tool 10. However, and as is well known to those skilled in the art, cementing operations are designed for each individual well so that the physical conditions present in that well can be taken into account. These conditions, such as bottom hole temperature, the presence of a weak, easily fracturable formation, pressures, and so forth, dictate the type of cement slurry to be used and the manner and position that the slurry will be placed in the annular space. For example, a particular cementing operation may require use of two cementing tools in the string of casing so that three quantities of slurry can be "spotted" behind the casing with drilling mud separating each quantity. Other examples can be given, however the above suffices to demonstrate that cementing operation described relative to the preferred embodiment is not to be considered as limiting the present invention.

Although the invention has been described with reference to the embodiment illustrated, it will be appreciated by those skilled in the art that additions, modifications, substitutions, deletions, and other changes not specifically described may be made which fall within the spirit of the invention as defined in the following claims.
What is claimed is:
1. Dual sleeve cementing apparatus for multiple stage cementing of a wellbore comprising:
a tubular cylindrical housing having one or more ports through the wall thereof;
opening sleeve means slidably located in said housing, said opening sleeve means being located in a first position covering said one or more ports and slidable to a second position thereby uncovering said one or more ports;
closing sleeve means slidably located in said housing arranged to slide from a first position wherein said one or more ports are not covered by said closing sleeve means to a second position covering said ports;
first shearable means retaining said opening sleeve means within said housing, said first shearable means comprising an annular shear ring partially inset in an annular grooved recess in the inner wall of said housing, with the remainder of said annular shear ring being inset in an exterior annular recess in said opening sleeve means;
second shearable means retaining said closing sleeve means within said housing, said second shearable means comprising an annular shear pin retaining ring concentrically located in an annular space between said closing sleeve means and said housing, with said retaining ring being removably attached to said closing sleeve means by one or more shear pins passing through said ring and into said closing sleeve means, and said retaining ring being unattached to said housing, with downward movement of said ring in said housing being prevented by abutment shoulder means on the interior wall of said housing, said abutment shoulder means arranged to abut the lower edge of said retaining ring, limiting downward movement thereof;
opening means providing a differential pressure area across the entire inner bore of said housing;
closing means providing a differential pressure area across the entire inner bore of said housing; and
said first and second shearable means arranged within said housing so as not to penetrate through the wall thereof.
2. The apparatus of claim 1 wherein said opening sleeve means and said closing sleeve means each comprise a nondrillable metallic sleeve having an inner bore as large or larger than that of the casing string containing said cementing apparatus;
said opening means comprises a first drillable valve seat collar fixedly attached in the interior bore of said opening sleeve nondrillable metallic sleeve and having a symmetrical beveled inner seat therein and a bore opening therethrough; and
said closing means comprises a second drillable valve seat collar fixedly attached in the interior bore of said closing sleeve nondrillable metallic sleeve and also having a symmetrical beveled inner seat therein and having a bore opening therethrough generally larger than the bore opening through said first drillable valve seat collar.
3. The apparatus of claim 1 wherein said opening means comprises a first beveled inner seat collar located in said opening sleeve means, said collar adapted to receive and sealingly engage a first cementing plug in said beveled seat thereof, so that when said first cementing plug sealingly engages said first inner seat collar the apparatus is rendered capable of distributing fluidic pressure across the entire inner bore of said housing;
said closing means comprises a second beveled inner seat collar located in said closing sleeve means, said second collar adapted to receive and sealingly engage a second cementing plug, so that when said second cementing plug sealingly engages said second inner seat collar the apparatus is rendered capable of distributing fluidic pressure across the entire inner bore of said housing;
said opening sleeve means movable only between a first shearably attached position to a second non-shearably fixed position; and
said first cementing plug having pressure relief means therethrough for preventing fluid lock between said first cementing plug and said second cementing plug.
4. A dual sleeve oil well cementing valve for installation in a well casing string comprising:
a cylindrical nondrillable tubular housing having an inner bore therethrough having a diameter generally larger than the diameter of the bore of the casing string in which it is to be installed;
one or more cementing ports through the wall of said housing communicating the inner bore of said housing with the annular area outside said housing;
a first nondrillable slideable tubular sleeve inside said housing arranged to be movable from a first position covering said ports to a second position uncovering said ports;
said first sleeve having an inner bore diameter generally equal to or larger than said casing bore diameter;
a first drillable valve seat collar fixedly attached to the interior of said first sleeve and having an open bore therethrough and an upwardly facing inner annular beveled seat therein adapted to sealingly receive a cementing plug;

a second nondrillable slideable tubular sleeve located within said housing above said first nondrillable sleeve and having an inner bore diameter generally equal to or larger than that of the well casing and arranged to be above said ports in an initial position and movable to a second position covering said ports;
a second drillable valve seat collar fixedly attached to the interior of said second sleeve and having an open bore therethrough larger than that of said first drillable valve seat collar, and an upwardly facing inner annular beveled seat therein adapted to sealingly receive a second cementing plug;
a shear pin retaining ring annularly located between said housing and said second nondrillable sleeve, and removably attached to said second sleeve by one or more shear pins passing through said ring and into said second sleeve;
an annular shoulder on the interior wall of said housing below said retaining ring, arranged to abut said ring and limit downward movement thereof within said housing;
an annular shear ring located in annular recesses in said first sleeve and said housing and arranged to temporarily attach said first sleeve to said housing;
first seal means between said first sleeve and said housing for selectively preventing fluid communication between said ports and the inner bore of said first sleeve;
second seal means between said second sleeve and said housing for selectively preventing fluid communication between said ports and the inner bore of said second sleeve; and locking means between said second sleeve and said housing and arranged to engage an annular recess in said housing in said lower position of said second sleeve thereby preventing upward movement of said second sleeve within said housing.