SPECIFICATION

Cementing head apparatus and method of injecting a cementing plug into a well casing

The invention relates to an apparatus and method for cementing of a well casing in a borehole. More specifically, the invention resides in a cementing head apparatus for injecting a cementing plug into the well casing.

In a typical well cementing operation, a bottom cementing plug is introduced into the well casing ahead of the cement slurry. After the desired amount of cement slurry has been injected into the well casing, another plug, usually called a top plug, follows immediately behind the slurry column as it travels down the well casing. The function of the top and bottom plugs is to separate the cement slurry column from drilling muds and other fluids which can contaminate the slurry. Drilling mud or some other fluid is then pumped into the casing behind the top plug to push the cement slurry through the casing and up into the annulus between the casing and the borehole.

The cementing heads presently in use for injecting cementing plugs into a well casing are not entirely satisfactory. A primary reason is that most of the cementing heads now in use require that an operator on the rig floor inject the plug into the well casing, at the appropriate time, using a manual procedure. Because these cementing heads do not have a positive means for indicating that the plug has been injected into the casing, it can create a very hazardous situation for the operator if the plug should hang up in the head itself, or in the well casing. In addition to being unsafe, the situation described above can result in a substantial waste of material (cement slurry), and a waste of time required to shut down the cementing operation and clean up the equipment.

The present invention resides in a cementing head apparatus for injecting a cementing plug into a well casing, the apparatus comprising:

a head unit 10 including a plug housing 11, a baffle member 16 secured inside the plug housing, a cementing plug assembly mounted in the baffle member and retained by a shear means 21;

the plug housing having a first fluid inlet port 14 located above the baffle member, and a second fluid inlet port 22 located below the cementing plug assembly;

the plug housing including a coupling means 26 adapted for connecting the well casing 25 to the head unit;

a manifold unit having a first fluid outlet port 15 adapted for coupling to the first fluid inlet port 14, and a second fluid outlet port 45 adapted for coupling to the second fluid inlet port 22;

a tubular mandrel 35 having a shoulder 35a thereon, the mandrel being slidably positioned within the manifold unit to a closed position for closing the second fluid outlet port 45 and to an open position for opening the second fluid outlet port;

an annular chamber 36 between the outer wall of the mandrel and the manifold unit;

the annular chamber having first and second fluid inlet ports in communication with a source of fluid for moving the mandrel between the open and closed positions; and

said manifold unit being adapted for connection to a cement pump.

The present invention also resides in a method for injecting a cementing plug into a well casing, comprising the steps of:

positioning a cementing plug in the plug housing of a cementing head unit, said plug being retained in the plug housing by a shear means;

connecting the plug housing to a well casing, the connection being made below the cementing plug;

simultaneously pumping a cement slurry into the plug housing above the cementing plug and into the plug housing and the well casing below the cementing plug at a constant flow rate to apply an equal pressure in the plug housing above and below the cementing plug;

allowing a pre-determined amount of the cement slurry to be pumped into the well casing;

stopping flow of the cement slurry into the plug housing;

pumping a stream of fluid into the plug housing above the cementing plug under a pressure sufficient to rupture the shear means; and

continuing to pump said fluid stream above the cementing plug at the same pressure to cause the cementing plug to follow the cement slurry into the well casing.

More specifically, the apparatus is made up of a head unit and a manifold unit. The head unit includes a plug housing with a baffle member secured inside the housing. A cementing plug assembly is mounted in the baffle and retained by a shear means. The plug housing has two fluid inlet ports; one port is located above the baffle, and the other one below the cementing plug assembly. The plug housing also includes a coupling means specifically designed for connecting the well casing into the head unit.

The manifold unit includes an upper manifold housing and a lower manifold housing coupled to the upper housing. The lower manifold housing is also adapted for connection to a cement supply apparatus. There are two fluid outlet ports in the upper manifold housing. One outlet port is adapted for coupling to the inlet port above the baffle and the other outlet port is adapted for coupling to the inlet port located below the cementing plug assembly.

The manifold unit also includes a tubular mandrel which has an outwardly projecting shoulder. The mandrel is positioned with a slide fit inside the upper and lower manifold housing. The mandrel is adapted to slide to one position to close off the inlet port located below the cementing plug assembly and to another position which allows fluid to enter this same inlet port. The inside diameter of the manifold housing is larger than the outside diameter of the mandrel to provide a space between the mandrel and the housing defining an annular chamber. This

chamber has two inlet ports which are connected to a source of fluid for moving the mandrel to open or close the inlet port described above.

Description of the Drawings

Figure 1 is a front elevation view, mostly in section, of a cementing head apparatus according to this invention.

Figure 2 is a partial detail view of the cementing head apparatus of Figure 1. This Figure illustrates a mandrel in the cementing head, when the mandrel is in its open position.

Figure 3 is another partial detail view of the cementing head apparatus of Figure 1. This Figure illustrates an arrangement for connecting the cementing head unit onto a well casing section which has a short coupling.

Referring to Figure 1, the cementing head of this invention is indicated generally by reference numeral 10. The basic structure of this apparatus is made up of a head unit and a manifold unit. The head unit includes a plug housing 11, which is closed at the top by a threaded cap 12. In closed position, cap 12 is sealed against housing 11 by an O-ring 13.

Housing 11 has a fluid inlet port 14 in one side of the housing, the port being located immediately below the cap 12. A nipple connection 15 is welded to the outer wall surface of housing 11, so that it lines up with the inlet port 14. Nipple 15 is threaded at its outer end, to accept a union coupling 44. Inside the housing 11 is a baffle plate 16, which is seated in the housing immediately below the inlet port 14. The baffle plate 16 seats on a narrow shoulder 17 in housing 11 and is held against the shoulder 17 by at least two hold down studs 18, which thread into cap 12. Only one of the hold down studs 18 is shown in the drawing.

An O-ring 19 provides a fluid tight seal between the baffle plate 16 and housing 11. The baffle plate 16 has a central opening in which a cementing plug assembly is mounted. The top part of the cementing plug assembly is a cap 20, which includes a threaded stem 20a. The bottom part of the cementing plug assembly is the cementing plug itself, indicated at 20b. The stem 20a on cap 20 threads down into the cementing plug 20b. The cap and stem are fabricated of a material which can be drilled out of a well casing, such as aluminum, or synthetic plastic resin compositions. An O-ring 21 provides a means for mounting the cap 20 in the center opening of baffle plate 16. The O-ring 21 also provides a shearable connection which allows the plug 20b to break loose from baffle 16 during the cementing operation. The shearing sequence is explained in more detail later.

A second fluid inlet port 22 is located in the housing 11 below the cementing plug 20b. In addition, a second nipple connection 23 is welded onto the outer wall surface of housing 11, so that the nipple lines up with port 22. The nipple 23 has external threads for engagement with a union coupling 47. The bottom end of plug housing 11 has a coupling means specifically designed for connecting into the top end of the well casing 25. The top section of each well casing usually includes a coupling which is threaded over the top end of the casing section, for connection into the housing 11. Some casing sections are equipped with a long coupling 25a; and other sections will have a short coupling 25b at the top end.

The coupling structure for connecting into a long coupling 25a is illustrated in Figure 1. The several parts of the connecting structure include a make-up cap 26, an upper wedge ring 27, lower wedge ring 28, and a retainer member 29. When the long coupling connection is made, a boss member 27a on ring 27 rides in an inclined slot 30 at the bottom end of plug housing 11. This arrangement allows the front face of ring 27 to wedge against the long coupling 25a. Wedge ring 27 also has an expander spring (not numbered), which sets in the wedge ring and encloses the long coupling 25a.

The lower wedge ring 28 also includes a boss member 28a. This boss member rides in an inclined slot 29a in the retainer member 29. When cap 26 is threaded onto housing 11, the top face of ring 28 wedges against the bottom face of ring 27 and also against the lower lip of coupling 25a. The wedge ring 28 also has an expander spring (not numbered) seated within the wedge ring and enclosing the long coupling 25a. In addition, a flat ring 31 is seated in a groove in cap 26. When the connection is made, ring 31 bears against the top face of the retainer member 29, thus providing a hold down means for the retainer member. A set of seals 32 provide a fluid-tight seal between the lower end of housing 11 and the long coupling 25a.

The coupling arrangement for connecting into a well casing having a short coupling 25b is illustrated in Figure 3. As shown in Figure 3, this coupling arrangement utilizes the same parts which are used in making the connection into the long coupling 25a. However, because the coupling 25b has a shorter length than the long coupling, the actual arrangement of the parts in each of the connecting structures is slightly different. For example, as shown in Figure 3, when cap 26 is threaded onto housing 11, for the short coupling connection, the top face of ring 27 wedges against the lower lip of coupling 25b. At the same time, the top face of ring 28 engages the bottom face of ring 27, and the inner surfaces of both wedge rings are urged against the well casing 25.

Basic parts of the manifold unit include an upper manifold housing 33, a lower manifold housing 34, and a tubular mandrel 35. The mandrel also has a shoulder 35a, which is defined on the outer wall surface of the mandrel. The top end of lower housing 34 threads into the bottom end of the upper housing 33. Mandrel 35 is fitted inside of housings 33 and 34, with a slide fit to enable it to move up and down within the housings. Near the top end of housing 34 an annular space 36 is defined between the inner wall surface of the housing and the outer wall surface of mandrel 35. This annular space 36

provides a chamber for receiving and directing a fluid against the mandrel shoulder 35a.

A fluid inlet line 38 is connected by a coupling 37 into the bottom end of the manifold housing 34. The opposite end of line 38, not shown, can be connected to a pump, or other apparatus, for delivering a cement slurry or other treating fluid into the manifold unit. At least two openings 39 are located in housing 34 slightly above the bottom end of the housing. These openings provide sight ports which enable the operator to see an indicater mark (not shown) which is painted or stamped on the outer wall surface of the mandrel. This is to provide a means for the operator to determine whether the mandrel is in its open or closed position.

At the bottom of chamber 36, the chamber is in direct communication with a fluid inlet port 40, which extends through the wall of housing 34. A similar fluid inlet port 41, extending through the wall of housing 34, is in direct communication with the top end of chamber 36. A hydraulic fluid line 42 is connected by an appropriate fitting to the inlet port 40. A second hydraulic fluid line 43 is also connected by a fitting to the inlet port 41. At its top end the upper manifold housing 33 provides a fluid outlet port which communicates with the fluid inlet port 14 in plug housing 11. The top end of housing 33 is coupled to a nipple connection 15 by a union coupling 44.

Housing 33 includes a second fluid outlet port 45, which is positioned slightly above the lower end of the housing. A nipple connection 46 is welded to the outer wall surface of housing 33 such that the nipple is in direct alignment with port 45.

A second union coupling 47 connects the nipple 46 to nipple 23 to provide communication between the outlet port 45 in the manifold unit and the inlet port 22 in the head unit. In this connecting structure a fluid seal ring 48 comprised of a material such as a hard rubber composition is compressed between the end of nipple 46 and nipple 23. Behind this seal ring is a backing ring 49 which is held against a shoulder on nipple 46 by an outer coupling member 50, which threads over the nipple 23. Ring 49 and the coupling member 50 are tied together by a retainer ring 51. Several O-rings (not numbered) are fitted around the mandrel 35 to provide a fluid tight seal between the mandrel and the upper and lower manifold housings.

The invention can be illustrated by describing a typical cementing operation using the cementing head apparatus described herein. At the start of the operation, the cementing plug 20b is "loaded" into the plug housing 11. This is done by mounting cap 20 in the baffle plate 16 and securing the cap to the plate with the shearable O-ring 21. The head unit 10 is then secured to the top coupling (long coupling 25a, or short coupling 25b) of the well casing 25. The fluid inlet line 38 is connected by coupling 37 to the lower manifold housing 34. At the opposite end, line 38 is connected to a pump.

Before a treating fluid or cement slurry is pumped into the well casing 25, the mandrel 35 is in its "open" position. In the open position, which is illustrated in Figure 2, the mandrel rests at its lowest position within the manifold housings 33 and 34. When the mandrel is at this point, the top end of the mandrel lies slightly below the outlet port 45, so that the port is completely open. The cement slurry is then pumped through the head 10 into the well casing 25. With the outlet port 45 being open, most of the cement slurry will flow through the outlet port 45, the inlet port 22 and into the well casing 25. However, part of the cement slurry stream will pass upwardly through the manifold housing 33 and through inlet port 14. The result is a build up of the slurry in the "head space" defined in housing 11 above the baffle plate 16 and cap 20.

During the pumping operation, the force exerted by the cement slurry will be the same both above and below the cementing plug assembly. Because the slurry pressure is in balance on both sides of the cementing plug assembly, the cap 20 will remain secured to the baffle plate 16 by O-ring 21. The objective of this design feature is to prevent the cementing plug 20b from being pushed down the well casing prematurely.

After the desired amount of cement slurry has been pumped into the well casing, the operator cuts off the slurry flow from the pumper. At the same time he activates a hydraulic fluid pressure unit and valve (not shown), which is connected to chamber 36 by the fluid inlet lines 42 and 43. This allows hydraulic fluid to enter chamber 36 through the lower inlet port 40, and push upwardly against the bottom face of the mandrel shoulder 35a. The fluid pressure applied is high enough to move the mandrel upwardly far enough to close off the outlet port 45. With the mandrel in the closed position, as illustrated in Figure 1, the operator switches to a fluid dispensing apparatus which is connected to the inlet line 38. This allows a fluid to flow through manifold housing 33 and inlet port 14 and into the head space above the cementing plug assembly.

Pumping of this fluid is continued until the fluid pressure is high enough to rupture (shear) the O-ring 21. When the O-ring is sheared off from baffle plate 16, the cap 20 and cementing plug 20b will follow the cement slurry down well casing 25. A pressure gauge on the fluid dispensing apparatus enables the operator to observe the amount of fluid pressure exerted against the cementing plug assembly. When the O-ring 21 is sheared off from the baffle plate 16, there will be an immediate pressure drop on the gauge. This gives the operator a positive indication that the cementing plug has separated from the baffle plate 16 and followed the slurry into the well casing.

If the cementing plug 20b should get hung up in the housing 11 or in the well casing 25, the gauge will immediately indicate a sudden rise in pressure. If this should happen, the operator can immediately shut down the entire operation.

After a cementing operation is completed, the

mandrel 35 is returned to the open position (illustrated in Figure 2) before another job is commenced. To return the mandrel to the open position, the operator first closes the valve controlling flow to line 42, and opens another valve (not shown) which regulates flow into line 43. This allows the hydraulic fluid to flow into chamber 36 through port 41 and push downwardly against the top face of the mandrel shoulder 35a. The amount of fluid pressure applied is sufficient to move the mandrel downwardly far enough for the top of the mandrel to be clear of the outlet port 45, as described earlier.

As mandrel 35 moves upwardly to its closed position, and downwardly to its open position, residual hydraulic fluid will accumulate in chamber 36 both above and below shoulder 35a. When the mandrel moves upwardly, as shown in Figure 2, the hydraulic fluid above the shoulder will be pushed back into the inlet line 43. Conversely, when the mandrel moves downwardly, as shown in Figure 2, the hydraulic fluid below the shoulder will be pushed back into the inlet line 42.

CLAIMS

1. A cementing head apparatus for injecting a cementing plug into a well casing, the apparatus comprising:

a head unit (10) including a plug housing (11), a baffle member (16) secured inside the plug housing, a cementing plug assembly mounted in the baffle member and retained by a shear means (21);

the plug housing having a first fluid inlet port (14) located above the baffle member, and a second fluid inlet port (22) located below the cementing plug assembly;

the plug housing including a coupling means (26) adapted for connecting the well casing (25) to the head unit;

a manifold unit having a first fluid outlet port (15) adapted for coupling to the first fluid inlet port (14), and a second fluid outlet port (45) adapted for coupling to the second fluid inlet port (22);

a tubular mandrel (35) having a shoulder (35a) thereon, the mandrel being slidably positioned within the manifold unit to a closed position for closing the second fluid outlet port (45) and to an open position for opening the second fluid outlet port;

an annular chamber (36) between the outer wall of the mandrel and the manifold unit;

the annular chamber having first and second fluid inlet ports (40 and 41) in communication with a source of fluid for moving the mandrel between the open and closed positions; and

said manifold unit being adapted for connection to a cement pump.

2. A cementing head apparatus as claimed in claim 1 wherein the cementing plug assembly comprises a stem cap (20) including a threaded stem (20a), and a cementing plug (20b) fastened to said threaded stem, said shear means comprising an O-ring (21) between the stem cap and the baffle member (16).

3. A cementing head apparatus as claimed in claim 1 or claim 2 in which the mandrel is moved to its closed position by directing fluid through the first inlet port (40) in the annular chamber (36) so that the fluid pressure is applied to the bottom face of the mandrel shoulder (35a), and in which the mandrel (35) is moved to its open position by directing fluid through the second inlet port (41) in the annular chamber so that the fluid pressure is applied to the top face of the mandrel shoulder.

4. A cementing head apparatus as claimed in any one of the preceding claims in which the well casing (25) is connected to the plug housing (11) with a cap member (12) which threads onto the plug housing and which encloses the top end of the well casing (25), the connection including a first wedge member (27) which seats against the upper end of the well casing and the plug housing, and a second wedge member (28) which seats against the first wedge member, the upper end of the well casing, and a retainer member (29) positioned inside the cap member.

5. A cementing head apparatus as claimed in any one of the preceding claims wherein said manifold unit includes an upper manifold housing (33) and a lower manifold housing (34) coupled to the upper manifold housing, said lower manifold housing (34) having at least one sight port (39) therein, and wherein the tubular mandrel (35) has a first indicator mark thereon which is visible through the sight port when the mandrel is in its closed position, and a second indicator mark which is visible through the sight port when the mandrel is in its open position.

6. A method for injecting a cementing plug into a well casing, comprising the steps of:

positioning a cementing plug in the plug housing of a cementing head unit, said plug being retained in the plug housing by a shear means;

connecting the plug housing to a well casing, the connection being made below the cementing plug;

simultaneously pumping a cement slurry into the plug housing above the cementing plug and into the plug housing and the well casing below the cementing plug at a constant flow rate to apply an equal pressure in the plug housing above and below the cementing plug;

allowing a pre-determined amount of the cement slurry to be pumped into the well casing;

stopping flow of the cement slurry into the plug housing;

pumping a stream of fluid into the plug housing above the cementing plug under a pressure sufficient to rupture the shear means; and

continuing to pump said fluid stream above the cementing plug at the same pressure to cause the cementing plug to follow the cement slurry into the well casing.

7. A cementing head apparatus as claimed in claim 1 substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

mandrel 35 is returned to the open position (illustrated in Figure 2) before another job is commenced. To return the mandrel to the open position, the operator first closes the valve controlling flow to line 42, and opens another valve (not shown) which regulates flow into line 43. This allows the hydraulic fluid to flow into chamber 36 through port 41 and push downwardly against the top face of the mandrel shoulder 35a. The amount of fluid pressure applied is sufficient to move the mandrel downwardly far enough for the top of the mandrel to be clear of the outlet port 45, as described earlier.

As mandrel 35 moves upwardly to its closed position, and downwardly to its open position, residual hydraulic fluid will accumulate in chamber 36 both above and below shoulder 35a. When the mandrel moves upwardly, as shown in Figure 2, the hydraulic fluid above the shoulder will be pushed back into the inlet line 43. Conversely, when the mandrel moves downwardly, as shown in Figure 2, the hydraulic fluid below the shoulder will be pushed back into the inlet line 42.

CLAIMS

1. A cementing head apparatus for injecting a cementing plug into a well casing, the apparatus comprising:

a head unit (10) including a plug housing (11), a baffle member (16) secured inside the plug housing, a cementing plug assembly mounted in the baffle member and retained by a shear means (21);

the plug housing having a first fluid inlet port (14) located above the baffle member, and a second fluid inlet port (22) located below the cementing plug assembly;

the plug housing including a coupling means (26) adapted for connecting the well casing (25) to the head unit;

a manifold unit having a first fluid outlet port (15) adapted for coupling to the first fluid inlet port (14), and a second fluid outlet port (45) adapted for coupling to the second fluid inlet port (22);

a tubular mandrel (35) having a shoulder (35a) thereon, the mandrel being slidably positioned within the manifold unit to a closed position for closing the second fluid outlet port (45) and to an open position for opening the second fluid outlet port;

an annular chamber (36) between the outer wall of the mandrel and the manifold unit;

the annular chamber having first and second fluid inlet ports (40 and 41) in communication with a source of fluid for moving the mandrel between the open and closed positions; and

said manifold unit being adapted for connection to a cement pump.

2. A cementing head apparatus as claimed in claim 1 wherein the cementing plug assembly comprises a stem cap (20) including a threaded stem (20a), and a cementing plug (20b) fastened to said threaded stem, said shear means comprising an O-ring (21) between the stem cap and the baffle member (16).

3. A cementing head apparatus as claimed in claim 1 or claim 2 in which the mandrel is moved to its closed position by directing fluid through the first inlet port (40) in the annular chamber (36) so that the fluid pressure is applied to the bottom face of the mandrel shoulder (35a), and in which the mandrel (35) is moved to its open position by directing fluid through the second inlet port (41) in the annular chamber so that the fluid pressure is applied to the top face of the mandrel shoulder.

4. A cementing head apparatus as claimed in any one of the preceding claims in which the well casing (25) is connected to the plug housing (11) with a cap member (12) which threads onto the plug housing and which encloses the top end of the well casing (25), the connection including a first wedge member (27) which seats against the upper end of the well casing and the plug housing, and a second wedge member (28) which seats against the first wedge member, the upper end of the well casing, and a retainer member (29) positioned inside the cap member.

5. A cementing head apparatus as claimed in any one of the preceding claims wherein said manifold unit includes an upper manifold housing (33) and a lower manifold housing (34) coupled to the upper manifold housing, said lower manifold housing (34) having at least one sight port (39) therein, and wherein the tubular mandrel (35) has a first indicator mark thereon which is visible through the sight port when the mandrel is in its closed position, and a second indicator mark which is visible through the sight port when the mandrel is in its open position.

6. A method for injecting a cementing plug into a well casing, comprising the steps of:

positioning a cementing plug in the plug housing of a cementing head unit, said plug being retained in the plug housing by a shear means;

connecting the plug housing to a well casing, the connection being made below the cementing plug;

simultaneously pumping a cement slurry into the plug housing above the cementing plug and into the plug housing and the well casing below the cementing plug at a constant flow rate to apply an equal pressure in the plug housing above and below the cementing plug;

allowing a pre-determined amount of the cement slurry to be pumped into the well casing;

stopping flow of the cement slurry into the plug housing;

pumping a stream of fluid into the plug housing above the cementing plug under a pressure sufficient to rupture the shear means; and

continuing to pump said fluid stream above the cementing plug at the same pressure to cause the cementing plug to follow the cement slurry into the well casing.

7. A cementing head apparatus as claimed in claim 1 substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

8. A method for injecting a cementing plug into a well casing as claimed in claim 6 substantially as hereinbefore described with reference to the accompanying drawings.

9. A well casing whenever cemented by a method as claimed in claim 6 or claim 8.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1983. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.