MULTI-ZONE FRAC-PACKING USING SCREEN-CONVEYED LINEAR CHARGES

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ABSTRACT
An assembly is disclosed which is usable with the well which comprises a base pipe having a plurality of apertures where each of the apertures contains a screen insert. The assembly also includes a plurality of perforating charges which are mounted to the outer surface of the base pipe in proximity to the screen inserts. In one embodiment, the perforating charges are conical shaped charges, while in another embodiment, the perforating charges are linear shaped charges. An assembly according to the present invention may be utilized to perforate and gravel pack one or more of downhole zones in a single trip downhole. Utilization of linear perforating charges avoids killing the well and prevents formation damage by kill pills or kill fluids. An assembly in accordance with the present invention thus reduces drilling time and costs and allows for total flexibility for the distance between stacked intervals.
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CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is a continuation of application Ser No. 11/380,755, filed Apr. 28, 2006.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention generally relates to a completion system for a wellbore, and, more particularly, to a sand-face completion for the wellbore.

[0004] 2. Description of the Prior Art

[0005] In order to perforate and gravel pack a wellbore, several downhole trips or runs, typically are required. For example, a lower zone is plugged, then perforated, and the perforating guns are recovered. Then a clean-up string is then tripped in the hole, and recovers the plug. Thereafter, a string that contains a bottom-hole assembly is run into the well, and the bottom-hole assembly typically includes the sand screen to support a filler gravel substrate that is deposited around the sand screen in a subsequent gravel packing operation. The portion of the string above the bottom-hole assembly, which is generally referred to as the “running string,” is then retrieved from the well upon the completion of the gravel packing operation.

[0006] Fluid loss in the well increases with the number of downhole trips, because fluid loss invades the formation and may have detrimental effects on the well. Thus, a continuing need exists for better ways to reduce the number of trips into a well for purposes of performing completion operations such as perforating and gravel packing operations.

[0007] In U.S. application Ser. No. 11/380,755 filed Apr. 28, 2006, which is incorporated herein by reference, method and apparatus are described for performing perforating and gravel packing operations in a single trip or run downhole. The present application discloses substantial improvements on the method and apparatus described in application Ser. No. 11/380,755.

SUMMARY OF THE INVENTION

[0008] In accordance with the present invention, an assembly usable with the well is described. The assembly comprises a base pipe having a plurality of apertures where each aperture contains a screen insert. An assembly according to the present invention also comprises a plurality of perforating charges which are mounted to the outer surface of the base pipe in proximity to the screen inserts.

[0009] An assembly according to the present invention further comprises a detonating cord to communicate a detonating wave to the perforating charges. In one embodiment of the assembly of the present invention, the perforating charges are pressure isolated conical shaped charges or capsule charges, while in another embodiment of the invention the perforating charges are pressure isolated linear shaped charges. Each assembly comprising a perforating gun.

[0010] In accordance with the present invention, an assembly is also provided for treating multiple zones of a wellbore in a single run or trip downhole. Such an assembly comprises a base pipe having a plurality of tubular members with multiple separate groups of the tubular members having screen inserts and the groups with screen inserts having tubular members without inserts interposed between them. A plurality of perforating guns are provided, and one perforating gun is provided for each group of tubular members having screen inserts. Each perforating gun comprises a plurality of perforating charges in proximity to the screen inserts which may be detonated via a detonating cord which communicates a detonating wave to the perforating charges. In one embodiment of the assembly of the present invention, the perforating charges are capsule charges, while in another embodiment the perforating charges are linear shaped charges.

[0011] A method according to the present invention to perforate and gravel pack a plurality of zones of a well comprises the steps of placing a completion assembly across multiple zones. The completion assembly includes a service tool. For each zone to be gravel packed, the completion assembly includes a screen assembly and perforating charges. Each of the zones to be gravel packed is bounded by a packer above and below the zone. The perforating charges associated with the first zone to be gravel packed are detonated after the packer for that zone has been set. Thereafter, slurry is then communicated through the assembly to perform a gravel packing operation in the zone to be gravel packed. For each subsequent zone to be gravel packed, the service tool is repositioned to that zone and the steps of detonating the perforating charges and communicating a slurry through the assembly are repeated for that zone.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] In the accompanying drawings:

[0013] FIG. 1 is an elevation view in partial cross-section of a well containing apparatus according to the present invention.

[0014] FIG. 2 is a perspective view of a portion of a tubular member containing apertures with screen inserts.

[0015] FIG. 3 is a cross-sectional view of one embodiment of a base pipe in an assembly according to the present invention.

[0016] FIG. 4 is a perspective view of an exemplary linear charge for use in the assembly of the present invention.

[0017] FIG. 5 is a cross-sectional view of a wellbore illustrating a base pipe that concentric with the casing and which contains linear charges.

[0018] FIG. 6 is a cross-section of a casing containing a base pipe where the base pipe and linear charges are eccentric with the casing.

[0019] FIGS. 7a-c are elevation views in partial cross-section of a well in which multiple zones of the wellbore are gravel packed with a single trip or run downhole.

DESCRIPTION OF THE SPECIFIC EMBODIMENTS

[0020] It will be appreciated that the present invention may take many forms and embodiments. In the following
description, some embodiments of the invention are described and numerous details are set forth to provide an understanding of the present invention. Those skilled in the art will appreciate, however, that the present invention may be practiced without those details and that numerous variations and modifications from the described embodiments may be possible. The following description is thus intended to illustrate and not to limit the present invention.

[0021] With reference first to FIG. 1, an exemplary embodiment of a bottom hole assembly (BHA) 45 in accordance with the present invention is illustrated. BHA 45 comprises a screen and perforating charge assembly 14 and a service tool 40. BHA 45 is lowered into wellbore 10 utilizing a tubular string (not shown in FIG. 1) that extends from the surface and is stabbed into the sump packer 32. As illustrated in FIG. 1, the wellbore 10 may be lined with casing 12. Those skilled in the art will recognize that while FIG. 1 depicts the wellbore 10 as being vertical, the apparatus and method described herein may likewise be applied to deviated and horizontal wellbores.

[0022] BHA 45, as further described below, may be utilized for isolating a particular zone, or interval of the wellbore 10; perforating that interval; communicating flows for purposes of gravel packing that interval, and communicating flows of produced reservoir fluids into the central lumen. Thus, the components of BHA 45 may form a single trip sand face completion system, and the advantages of consolidating downhole trips include the reduced rig time, reduced fluid loss and avoidance of detrimental effects that are attributable to fluid loss.

[0023] Referring to FIGS. 1 and 2, the screen and perforating charge assembly 14 of BHA 45 includes a base pipe 20 containing a plurality of apertures where each aperture comprises a screen insert 30. The screen insert 30 in each aperture permits the radial flow of fluid between the interior and exterior of base pipe 20 and vice versa. When flowing from the exterior to the interior, the screen insert prevents the ingress of particulates to the interior. Base pipe 20 may, for example, be fabricated by utilizing a plurality of tubular members 21 which have a plurality of apertures containing screen inserts 30 in conjunction with one or more tubular members 22 that do not have screen inserts, as illustrated in FIG. 1.

[0024] In one embodiment of the present invention, the tubular members 21 may be the FacsRITE brand™ sand screen which is available from Absolute Energy Solutions (AES) of Calgary, Canada.

[0025] In one embodiment, tubular member 21 may comprise a plurality of circumferential rows of screen inserts 30 as illustrated in FIG. 2. In another embodiment, tubular member 21 may comprise screen inserts 42 on only a portion of its outer surface as illustrated in FIG. 3.

[0026] Referring to FIGS. 1 and 2, screen/perforating charge assembly 14 comprises a plurality of perforating charges 31 which are mounted to the outer surface of each tubular member 21 in proximity to the screen inserts 30. In one embodiment, perforating charges 43 may be mounted between the rows of screen inserts 30 as illustrated in FIGS. 1-2. In the embodiment of FIG. 3, perforating charges 31 may be mounted on the portion of the outer surface of tubular member 21 that does not contain screen inserts.

[0027] In one embodiment, the perforating charges may, for example, be conical shaped charges. In yet another embodiment, the perforating charges may be linear shaped charges 44 as illustrated in FIG. 4. In each embodiment, a detonating cord interconnects the perforating charges and communicates a detonating wave to detonate the perforating charges.

[0028] The linear shaped charges mounted on the screens allow screen/perforating charge assembly 14 to be run into the well in total isolation from the formation. Once the BHA 45 is at depth, the packer 33 is set and then the linear charges 31 are detonated to create slot openings in the casing 12. The gravel pack operation can then proceed by pumping slurry into the slots via service tool 40 and overcoming fracture initiation pressure through the cement sheath and the formation itself. This procedure avoids killing the well and prevents formation damage by kill-pilfs or kill-liquids. This concept allows the execution of single trip perforating and gravel packing procedure without the need of a rat-hole, or sump, in the well below the perforated interval to allow for gun dropping. This reduces drilling time and costs and allows for total flexibility for the distance between stacked intervals.

[0029] With reference to FIG. 5, there is illustrated in cross-section of a base pipe 50 which is concentric with a casing 51 and which has a plurality of screen inserts 52 and a plurality of liner shaped charges 53 which are also concentrically located within the wellbore. In an alternative embodiment as illustrated in FIG. 6, the base pipe 60 may be eccentrically located with respect to the casing 61, which results in the linear charges 63 also being eccentrically located with respect to the casing. In this embodiment, base pipe 60 comprises a plurality of operations for receiving screen inserts 62.

[0030] With reference now to FIGS. 7a-c, method and apparatus are provided according to the present invention to perforate and gravel pack a plurality of zones of a well in a single trip downhole. In FIG. 7a, a wellbore 70 is illustrated contains a casing 71. A completion assembly is placed across each of the multiple zones that are desired to be treated by gravel packing. The completion assembly includes a service tool 73 and for each zone the completion assembly includes a screen and perforating charges assembly 74. The service tool 73 is initially operatively connected to the completion assembly associated with the lowest zone to be treated.

[0031] Still referring to FIG. 7a, a plurality of packers 75-77 are provided. Packers 75 and 76 bound the lowest zone to be treated, while packers 76 and 77 bound the next higher zone to be treated. All of the packers associated with the zones to be treated may be set simultaneously once the assembly has reached its lowest depth or the packers may be set sequentially as each zone is treated.

[0032] As illustrated in FIG. 7b, the perforating charges 78 associated with the first zone to be treated are detonated after the packers 75, 76 for that zone have been set. Thereafter, a slurry is communicated through the assembly as illustrated in FIG. 7c to perform a gravel packing operation in that first zone.

[0033] For each subsequent zone to be gravel packed, the service tool 73 is repositioned to the new zone and the steps of detonating the perforating charges and communicating a
slurry to perform a gravel packing operation are performed for that zone after the packers bounding that zone are set.

[0034] In one embodiment of the present invention, the perforating charges may be conical shaped charges, while in another embodiment of the invention, the perforating charges may be linear shaped charges. As illustrated in FIGS. 5 and 6, the base pipe may either be concentrically located with respect to the casing or eccentrically located with respect to the casing.

What is claimed is:

1. An assembly usable with a well, comprising:
   a base pipe comprising a plurality of apertures where each of the apertures contains a screen insert; and
   a plurality of perforating charges which are mounted to the outer surface of the base pipe in proximity to the screen inserts.

2. The assembly of claim 1, further comprising a detonating cord to communicate a detonating wave to the perforating charges.

3. The assembly of claim 2, wherein the perforating charges are conical charges.

4. The assembly of claim 2, wherein the perforating charges are linear shaped charges.

5. An assembly usable with a well, comprising:
   a base pipe comprising a plurality of tubular members with multiple, separate groups of said tubular members having screen inserts and said groups with screen inserts having tubular members without inserts interposed between them.
   a plurality of perforating guns, one for each group of tubular members with screen inserts, each perforating gun comprising a plurality of perforating charges.

6. The assembly of claim 5, further comprising a detonating cord to communicate a detonating wave to the perforating charges in a perforating gun.

7. The assembly of claim 6, wherein the perforating charges are conical shaped charges.

8. The assembly of claim 4, wherein the perforating charges are linear shaped charges.

9. A method usable to perforate and gravel pack a plurality of zones of a well, comprising the steps of:
   a) placing a completion assembly across multiple zones, where the completion assembly includes a service tool and where for each zone the completion assembly includes a screen assembly and perforating charges.
   b) bounding each zone with a packer above and below the zone;
   c) detonating the perforating charges associated with the first zone to be gravel packed after the packers bonding that zone have been set;
   d) communicating a slurry through the assembly to perform a gravel packing operation in the zone to be gravel packed; and
   e) for each subsequent zone to be gravel packed, repositioning the service tool to the zone and repeating steps (c) and (d) for that zone after the packers bounding that zone are set.

10. The method of claim 9, wherein the perforating charges are linear shaped charges.

11. The method of claim 10, wherein the well comprises a casing and wherein the base pipe is concentrically located with respect to the casing.

12. The method of claim 10, wherein the well comprises a casing and wherein the base pipe is eccentrically located with respect to the casing.

13. The method of claim 9, wherein all of the packers are set before the first zone is treated.

14. The method of claim 9, wherein the packers for each zone are set as the service tool progress through each zone.

15. A method usable to perforate and gravel pack a zone of a well, comprising the steps of:
   a) running an assembly using a service tool down into the well to the zone to be gravel packed, the assembly comprising a base pipe containing a plurality of apertures where each aperture contains a screen insert and a perforating gun located on the outside of the base pipe in proximity to the screen inserts where the perforating gun comprises a plurality of perforating charges;
   b) setting a packer above and below the zone to be gravel packed;
   c) detonating the perforating charges associated with the zone to be gravel packed; and
   d) communicating a slurry through the assembly to perform a gravel packing operation in the zone to be gravel packed.

16. The method of claim 15, wherein the perforating charges are linear shaped charges.

17. The method of claim 16, wherein the well comprises a casing and wherein the base pipe is concentrically located with respect to the casing.

18. The method of claim 16, wherein the well comprises a casing and wherein the base pipe is eccentrically located with respect to the casing.

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