METHOD AND APPARATUS FOR HYDRAULIC TREATMENT OF A WELLBORE

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Related U.S. Application Data
Provisional application No. 60/911,844, filed on Apr. 13, 2007.

Publication Classification
Int. Cl. E21B 3/124 (2006.01)
U.S. Cl. 166/281; 166/120

ABSTRACT
A method and apparatus for applying hydraulic treatment and diversion treatment to a wellbore are described. The method involves isolating a wellbore segment using hydraulic seals, applying fluid treatment and perforation diverters within the isolated segment; and scraping a portion of the wellbore after termination of treatment to remove any lodged perforation diverters from the wellbore. A collection chamber may also be provided for collecting used diverters for return to surface following treatment. In one embodiment, diverters used and collected within a first segment may be reused during treatment of a successive wellbore segment.
SET HYDRAULIC SEALS AROUND WELLBORE SEGMENT

DELIVER HYDRAULIC TREATMENT AND DIVERSION TREATMENT AS NEEDED WITHIN ISOLATED SEGMENT

UNSET HYDRAULIC SEALS

SCRAPE WELLBORE SEGMENT TO DISLODGE BALLS

FIG. 1
METHOD AND APPARATUS FOR HYDRAULIC TREATMENT OF A WELLBORE

CROSS REFERENCE TO RELATED APPLICATION

0001 This application claims the benefit under 35 U.S.C. 119(e) to U.S. provisional application No. 60/911,844, entitled “METHOD AND APPARATUS FOR HYDRAULIC TREATMENT OF A WELLBORE” filed Apr. 13, 2007, the disclosure of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

0002 The present invention relates generally to the application of hydraulic treatment to perforated wellbores. More particularly, the present invention relates to a method for delivering, distributing, and removing ball diverters within a wellbore to improve the effectiveness of the hydraulic treatment.

BACKGROUND OF THE INVENTION

0003 Oil and gas companies are continually seeking strategies to improve recovery from existing under-producing reserves, while also conducting new exploration to locate additional potential resources. Horizontal drilling and solvent or steam-assisted drainage methods have improved production in certain applications, while further applications have derived benefit from the development of new perforation, fractionation, and other stimulation treatments.

0004 Notably, hydraulic fracturing and stimulation treatment of cased wellbores has been improved by the use of diversion techniques, in which patent perforations along the wellbore are temporarily sealed or blocked by chemical or mechanical means such as diversion balls, foams, gels, filter cakes, and/or straddle packers to allow the treatment to open blocked or damaged perforations that may otherwise remain untreated and underproductive. Although such diversion techniques have generally improved recovery, chemical diversion is expensive and mechanical diverters pose other logistical difficulties such as the retrieval of used ball diverters from the well.

0005 The most common method of mechanical diversion involves the use of rubber or polymeric ball sealers, which are released downhole under pressure proximal to a patent perforation to lodge a ball sealer therewithin. The number of locations requiring sealing, number of ball sealers to apply, and time for treatment are determined prior to application of the ball sealers, and the pressure is monitored during treatment to confirm fracturing of all desired perforations. When the pressure rises rapidly without dissipating, it is assumed that all available perforations have been opened and blocked with ball sealers (known as bailout). At this point the treatment is terminated and the well is prepared for production. The operator may use a casing scraper to remove any lodged ball sealers from the casing, which are collected in the production fluid or simply permitted to drop downhole.

0006 As current methods of hydraulic treatment and diversion are generally applied to the entire wellbore at once, it is difficult to apply treatment to specific wellbore portions, and similarly, to ensure that each perforation has received the appropriate degree of treatment. Moreover, when ball sealers are used to divert hydraulic treatment, the balls may become lodged within a perforation, jamming or damaging tools, requiring additional runs of downhole equipment to dislodge the ball diverters or otherwise facilitate tool retrieval.

0007 Some of the problems encountered with the use of ball sealers have been addressed by the development of high and low density ball sealers as well as tools to apply both types of balls to appropriate downhole locations. For example, U.S. Pat. No. 4,194,561, U.S. Pat. No. 4,287,952, and Canadian Patent CA 1210686 describe the general use of high and low density ball sealers.

0008 Further, U.S. Pat. No. 7,059,407 describes an assembly for sequential perforation and fluid treatment of multiple wellbore segments without interruption to first remove perforating equipment from the wellbore. Although the assembly allows hydraulic treatment of specific wellbore segments, it does not provide a means to use ball sealers for diversion of fluid treatment within a wellbore segment.

0009 U.S. Pat. No. 7,134,505 describes a tubing string assembly that includes a number of segments, each bearing packer elements and fluid ports such that several segments of a wellbore may be isolated simultaneously and fluid treatment may be applied to each segment independently.

0010 U.S. Pat. No. 4,881,996 describes a tool for delivering fluid treatment and ball diverters to specific locations along a wellbore. The tool includes a packer, swivel, tubing tail with a centralizer, ball ejection port, and two circulating-washer cups. The system may be used to treat a series of locations along the wellbore, thereby minimizing the number of downhole trips made by the tool.

0011 U.S. published patent application 2006/0108117 describes a downhole cleaning tool deployed on a slickline or wireline, for removing debris from a wellbular. The tool is manipulated by jarring action at the surface, which moves brushes, scrapers, and wires into and out of contact with downhole surfaces to be cleaned. Debris is caught by a debris catcher or is carried to the surface during production.

0012 Although progress has been made in simplifying methods for effective fluid treatment of a wellbore, planning and proper execution of these treatments remains unpredictable and costly, with tools often becoming jammed downhole. It is, therefore, desirable to provide methods to simplify the process of hydraulic wellbore treatment.

SUMMARY OF THE INVENTION

0013 It is an object of the present invention to obviate or mitigate at least one disadvantage of previous wellbore fluid treatment methods and devices.

0014 In accordance with a first aspect of the invention, there is provided a method for applying hydraulic treatment to a wellbore comprising the steps of: reversibly setting hydraulic seals against a wellbore above and below a first wellbore segment of interest to isolate said first wellbore segment; delivering hydraulic treatment to the isolated wellbore segment; delivering perforation diverters to the isolated wellbore segment; terminating the delivery of treatment fluid to the isolated segment; unsetting the hydraulic seals from the wellbore; and scraping the wellbore segment to dislodge perforation diverters therefrom. The method may further comprise the step of collecting deployed perforation diverters from the wellbore.

0015 In a suitable embodiment, the hydraulic seals are pressure actuated sealing members. Further the hydraulic treatment may be fracturing fluid, acidizing or energizing treatment, proppants, or cleaning fluid and is applied in liquid state, gaseous state, or a combination of liquid and gaseous.
state and may further bear solids, waxes, biodegradables, or other particles suspended therewithin.

[0016] In an additional embodiment, the wellbore segment of interest bears two or more perforations, and perforation diverters are preferably delivered during hydraulic treatment of the segment.

[0017] In a further embodiment, the number of perforation diverters delivered to a particular segment is less than or equal to the number of perforations within the segment. In another embodiment, the number of perforation diverters delivered within the segment is greater than the number of perforations within the segment.

[0018] The perforation diverters for use in accordance with the invention are preferably ball sealers, which may be formed from polymeric or elastomeric materials, biodegradables, ceramics, composites or wax.

[0019] In a suitable embodiment of the invention, the step of scraping is performed by abrading the wellbore with a scraper. A diverter collection chamber may be operatively attached to the scraper for collecting used perforation diverters from the wellbore segment.

[0020] Alternatively, and particularly in treating uncased wellbores, the perforation diverters may include chemical diversion by gel or foam. In such embodiments, the gel or foam may be scraped from the wellbore using a wire brush scraper or other suitable scraping tool.

[0021] In a further embodiment, the method steps are repeated to isolate and treat a number of segments within the same wellbore. In such embodiment, deployed perforation diverters may be collected from each wellbore segment and returned to surface following treatment of all segments of interest. In a further embodiment, the perforation diverters delivered to one segment may be collected and redeployed downhole during the treatment of further wellbore segments by a tool specifically designed for this purpose. Accordingly, the method may further comprise the steps of: reversibly setting the hydraulic seals against the wellbore above and below a second wellbore segment of interest to isolate said second wellbore segment; applying hydraulic treatment to the isolated second segment; delivering perforation diverters to the isolated second segment; terminating the application of treatment fluid to the isolated segment; unsetting the hydraulic seals from the wellbore; and scraping the second wellbore segment to dislodge perforation diverters therefrom.

[0022] In an embodiment, one or more of the perforation diverters deployed within the first isolated segment is collected and then redeployed within the second isolated segment.

[0023] In accordance with a second aspect of the invention, there is provided an apparatus for use in hydraulic treatment of a wellbore, the apparatus comprising: upper and lower sealing assemblies for reversibly setting at least two hydraulic seals within a wellbore to isolate a portion of the wellbore between the seals; a hydraulic treatment assembly for applying a hydraulic treatment within the isolated portion of the wellbore; a diversion assembly operatively attached to the hydraulic treatment assembly for deploying perforation diverters within the isolated portion of the wellbore during hydraulic treatment; and a scraper assembly for scraping lodged perforation diverters from the wellbore segment.

[0024] In an embodiment, the upper and lower sealing assemblies include pressure-activated sealing members for sealing against the wellbore.

[0025] In another embodiment, the scraper assembly includes at least one scraper extending outwardly towards the wellbore to a radial distance less than or equal to the wellbore drift diameter. The scraper may be helically disposed about the longitudinal axis of the apparatus. Alternatively, two or more scrapers may be arranged radially about the apparatus.

[0026] A collection assembly may be associated with the scraper assembly for collecting deployed perforation diverters within the wellbore. The collection assembly may include a collection chamber having a collection port adjacent the scraper assembly such that scraping action directs used perforation diverters into the collection chamber through the collection port.

[0027] In a suitable embodiment, the hydraulic treatment assembly is continuous with the collection chamber such that when hydraulic treatment fluid is applied to the isolated wellbore segment, at least a portion of the treatment fluid passes through the collection chamber to cause perforation diverters within the collection chamber to be deployed to the isolated wellbore segment through the collection port.

[0028] In accordance with a third aspect of the invention, there is provided a diverter scraping and collection assembly for use in removing lodged perforation diverters from a wellbore, the assembly comprising: a tubular body for suspension within a wellbore; a scraping member extending radially from the tubular body for scraping a wellbore surface to remove lodged diverters therefrom; a collection chamber operatively attached to the tubular housing for collecting perforation diverters from the wellbore; and a diverter collection port adjacent the scraper and continuous with the collection chamber for directing dislodged perforation diverters to the collection chamber.

[0029] Other aspects and features of the present invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] Embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

[0031] FIG. 1 is a schematic diagram of a method in accordance with an embodiment of the invention;

[0032] FIG. 2 is a schematic cross-sectional view of a device in accordance with an embodiment of the invention; and

[0033] FIG. 3 is a perspective view of the device shown in FIG. 2; and

[0034] FIG. 4 is a schematic cross-sectional view of a device in accordance with a further embodiment of the invention.

DETAILED DESCRIPTION

[0035] Generally, the present invention provides a method and apparatus for hydraulic treatment of a wellbore including the use of perforation diverters to mechanically divert the treatment from patent perforations along the wellbore during treatment. Specifically, the method and apparatus of the invention provide a means for isolating a wellbore segment, delivering hydraulic treatment and perforation diverters to the segment as necessary, and scraping lodged diverters from the
wellbore. Used diverters may be collected following scraping and returned to surface for reuse.

Method Overview

[0036] With reference to FIG. 1, in an embodiment, the method of the invention generally includes the steps of: setting (100) hydraulic seals within a wellbore in two or more locations to isolate a wellbore segment between the seals; delivering (200) hydraulic treatment and diversion treatment to the isolated wellbore segment; scraping (300) the wellbore segment to remove any lodged diverters therefrom; and unsetting (400) the hydraulic seals from the wellbore. These steps may be repeated at successive locations along the wellbore without removing equipment from the wellbore.

[0037] As indicated in FIG. 1, the sequence of steps in the method may vary depending on the specific formations surrounding the wellbore and the degree of treatment desired. For example, several wellbore segments may be isolated and treated in succession without removing equipment from the wellbore, followed by scraping of the entire wellbore. Further, the wellbore may be scraped while the seals remain set rather than after the seals have been removed. Each step in the method may be performed on several successive wellbore segments in one trip downhole by an apparatus designed for this purpose, or in stages using several individual downhole devices. The apparatus and method described below are intended primarily for use with cased wellbores, however the method may also be useful with uncased wells using suitable diversion techniques such as gel or foamy-based diversion, with suitable hydraulic sealing assemblies, such as inflatable packer assemblies. In such methods, the scraper may be provided as a wire brush to adequately remove the gel or foam diverter.

Set Hydraulic Seals

[0038] The step of isolating a portion of the wellbore for specific and controlled treatment enables various segments of one wellbore to be treated individually and sequentially, without removing equipment to surface. Thus, customized treatments may be delivered at various locations along the wellbore simply by determining appropriate seal positioning for each treatment location desired.

[0039] Hydraulic seals are set along the wellbore above and below a zone of interest, to isolate same from the remainder of the wellbore. The zone of interest, or isolated segment, is generally a portion of the wellbore that has been previously perforated and to which hydraulic treatment such as fracturing or acidizing agents need be applied. The length of the isolated segment and number of perforations within the segment may vary depending on the phasing of the perforations along the wellbore and the characteristics of the surrounding formation.

[0040] The seals may be provided on a tubing string or other customizable assembly such that the seals are spaced apart as necessary to meet the needs for treatment of a particular wellbore. Suitable seals for use in accordance with the invention include weight-set, traction, or straddle packers, inflatable sealing devices, pressure-actuated deformable annular seals, or other known sealing devices suitable for use within a wellbore. The seals are preferably composed of elastomeric material suitable for use in the anticipated downhole temperature and pressure conditions. As such, it is preferable that the method be carried out using a number of operatively attachable subunits to enable substitution of appropriate sealing system subunits suitable for use in a specific situation.

[0041] Once the seals are set, hydraulic treatment is delivered specifically to the isolated segment under controlled pressure. Ball sealers may be similarly delivered as treatment progresses. When the treatment is terminated and pressure within the isolated segment dissipates, the seals are unset and may be relocated and reset to isolate another segment of the wellbore for treatment. Alternatively, if seals are already appropriately positioned throughout the wellbore, only the hydraulic treatment and diversion equipment need be lowered to the next appropriate segment, the corresponding seals set around the segment, and treatment may again be initiated.

Hydraulic Treatment and Diversion

[0042] Hydraulic treatments for use with the present method include any fluid stimulation treatments, whether liquid or gaseous, including fracturing fluid, proppants, stimulants, acidizing or energized fluid treatments, cleaning fluids, etc.

[0043] The perforation diverters intended for use with the present method include any removable mechanical perforation sealer, preferably ball sealers, which may be composed of biodegradable materials, polymers, elastomers, encapsulants, wax, or other suitable material.

[0044] When planning the stimulation treatment, the number and location of the wellbore segments to be isolated is determined and the volumes of fluid needed are estimated according to the operator’s desired parameters. Typically, an electric log will be run downhole prior to perforation (and in some situations prior to casing) to gather data regarding the characteristics of the surrounding formation. In addition, valuable information may be determined by examining cuttings during drilling, and gas detectors may be placed downhole during drilling to identify gas-bearing zones within the wellbore. Based on this type of data, the operator is able to estimate the degree of stimulation treatment required, and customize the presently described method accordingly.

[0045] When the hydraulic treatment is fracturing fluid, generally the fluid will first be applied alone to the isolated zone under pressure to determine whether any of the perforations remain open. If one or more perforations are open and accept fluid, as determined by monitoring the pressure as the treatment is applied, the operator may wish to divert treatment from these open perforations in order to stimulate any blocked perforations. Accordingly, perforation diverters may be delivered to the isolated wellbore segment. Typically, the number of diverters delivered will be fewer than the total number of perforations in the isolated segment, however in certain circumstances an excess of diverters may be used, for example 130% of the number of perforations. The operator continues to pump fluid into the isolated segment and carefully monitors the pressure within the segment. A spike in pressure followed by some degree of dissipation indicates that at least one new perforation has been fractured, which may be followed by delivery of further diverters to the segment.
When it has been determined that the wellbore has been fully treated, the treatment is terminated and the pressure within the isolated wellbore segment is released.

Scraping of Wellbore

When perforation diverters are delivered during hydraulic treatment of a wellbore segment, the diverters may become lodged within the perforations, protruding past the estimated drift diameter of tools used within the wellbore. When this occurs, downhole tools will contact the lodged diverter and may become damaged or jammed downhole. To avoid this problem, the method may include the step of scraping the wellbore to remove the diverters from the isolated segment.

Scraping of the wellbore is preferably performed immediately following cessation of the hydraulic treatment. Any diverters scraped from the wellbore are preferably collected to surface and may be redeployed for diversion within another treatment run. The scraping need not abrade the inner diameter of the wellbore, as effective removal of lodged perforation diverters may be achieved by scraping against the protruding portion of the lodged perforation diverter. Accordingly, it is sufficient to scrape with a device having a diameter less than or equal to the drift diameter of the wellbore.

Scraping of the wellbore may be accomplished by known methods, or using a tool designed for this purpose. It is preferable that the scraper be integrated with the hydraulic treatment delivery assembly to facilitate completion of the process without running additional tools downhole. The scraper should be somewhat pliable or deformable so it may be rotated and/or reciprocated as needed against the wellbore to dislodge diverters therefrom and avoid becoming jammed or stuck downhole.

Used Diverter Collection

In addition, the method may include the steps of collecting and retrieving deployed diverters from the isolated segment rather than simply allowing the used perforation diverters to flow to the surface with production fluid or drop downhole. In a preferred embodiment, the diverters are collected and stored during treatment of further wellbore segments.

In certain further contemplated embodiments, used ball diverters collected within the collection chamber may be redelivered to further wellbore segments for use in diversion. In such embodiments, used diverter collection may be a continual process whereby deployed diverters not functioning to divert treatment may be collected within the segment during treatment and redeployed during treatment of the same segment as a cyclical process to seal new perforations as they are opened during treatment.

Apparatus

A suitable apparatus for use in accordance with the invention includes an upper sealing assembly, a treatment assembly for delivering hydraulic treatment and diverters to a wellbore segment, a wellbore scraping assembly, and a lower sealing assembly. A diverter collection assembly may also be present for collecting used diverters within the wellbore.

Structure

With reference to FIGS. 2 and 3, an apparatus in accordance with an embodiment of the invention is shown in longitudinal cross section and in perspective view, respectively. The apparatus is generally composed of a series of threadably attached tubular components. Upper and lower sealing assemblies 20, 25, each bear two deformable pressure-actuated sealing members 21, 22 and 26, 27. The upper sealing assembly is attached to coiled tubing or jointed pipe through a safety shear sub and tubing connector (not shown) so the apparatus may be lowered to an appropriate wellbore depth and safely removed following treatment.

Disposed between the upper and lower sealing assemblies 20, 25 are the hydraulic treatment and diversion assembly 30, and the scraping and collection assembly 40. The treatment and diversion assembly supplies treatment fluid from surface, which is delivered to the isolated wellbore segment through port 31. Similarly, when diversion is required, ball diverters may be dropped from surface and delivered to the isolated wellbore segment along with the treatment fluid through port 31.

The scraping and collection assembly 40 bears scraper 41 and diverter collection port 42, which is continuous with collection chamber 43. Scraper 41 may be one or more annular rings spaced along the assembly, or a helical ring extending around the assembly. Alternatively, the scraper may be provided as a series of individual scraping blades or wire brushes spaced appropriately around the assembly. The scraper 41 preferably extends a distance such that the total diameter of the tool is approximately equal to the estimated wellbore drift diameter, not permitting sufficient space between the scraper and the wellbore for passage of a ball diverter. The scraper is therefore the widest rigid portion of the apparatus, and is preferably composed of material having suitable rigidity to effectively remove lodged ball diverters from the wellbore, while remaining deformable upon application of excessive force to enable removal of the apparatus from the wellbore should the scraper become jammed against a foreign object or surface. In embodiments in which the scraper is helical or segmented, with individual scrapers disposed about the assembly, the scraper need not be deformable, as rotation of the tool will allow avoidance of foreign objects or aberrations along the wellbore. Further, a second scraper may be present adjacent the upper sealing assembly 20 to allow bidirectional scraping as the apparatus is raised and lowered to abrade the wellbore.

The collection port 42 is located just above the scraper 41 to direct used ball diverters into the collection chamber 43 during scraping. In addition, as diverters are delivered to the isolated wellbore segment through port 31, some will become lodged within patent perforations along the wellbore, while others may be suspended within the fluid in the segment and/or fall towards the bottom of the isolated segment, where they will encounter scraper 41 and be directed to the collection port 42 and into collection chamber 43. Further, once treatment has been terminated and the wellbore is scraped, as lodged ball diverters are loosened by scraper 41, the used ball diverters will similarly be directed to collection port 42 and into collection chamber 43.

Apparatus 10 may be customized as necessary for use within a specific wellbore. Accordingly, it is preferable that the apparatus be assembled as a series of coupled subunits whereby additional components may be added or removed as necessary. In certain applications, a large collection chamber 43 may be required, which can be accommodated by inserting additional collection subas necessary between the scraper 41 and the lower sealing assembly 25.
Further, some applications may require delivery of hydraulic treatment within compact wellbore segments, while other applications may permit treatment of lengthy wellbore segments. This will depend on the preferences of the operator, the phasing of perforations within the wellbore, and the anticipated treatment pressure necessary to open perforations within the segment.

Operation

[0058] In use, a wellbore requiring hydraulic treatment is first analyzed to determine the number and length of wellbore segments to which hydraulic treatment is to be applied. Preferably, each segment contains 1 to 400 perforations and is between 0.1 and 20 metres in length. The apparatus shown in FIGS. 2 and 3 may be customized as necessary by adding or removing components to provide the appropriate distance between the upper and lower sealing assemblies, a suitable number and arrangement of sealing elements and scrapers, and an appropriate size for the collection chamber. If several segments of the wellbore are to be treated in succession, the collection chamber (if present) should be large enough to hold the anticipated total number of ball sealers to be used in treating all segments, as each segment will be scraped and balls collected within the collection chamber in series without removing the apparatus from the wellbore.

[0059] The apparatus is lowered, for example on coiled tubing, until the sealing systems 20, 25 straddle the lowest wellbore segment of interest. Treatment fluid is pumped through the coiled tubing to the segment through fluid port 31, until the pressure within the wellbore surrounding the apparatus reaches a threshold, activating the sealing systems 20, 25 to cause sealing members 21, 22, 26, 27 to flex or deform and seal against the wellbore, isolating the wellbore segment between the sealing systems for further treatment.

[0060] Treatment fluid is pumped to the isolated segment and the pressure is monitored. Once satisfactory treatment of patent perforations is achieved, typically as evidenced by a drop in pressure, ball sealers are delivered to the isolated segment through fluid port 31, along with continued treatment fluid. The ball sealers will seal against patent perforations within the isolated segment, diverting fluid to the untreated perforations. This process of applying treatment fluid and ball sealers is continued until the desired level of treatment is achieved.

[0061] When the operator has determined that treatment of the isolated segment is complete, the pumping of treatment fluid is terminated and the system is depressurized to unset the sealing systems 20, 25. Loose ball sealers will not be able to fall past the scraper 41, and will be guided into the collection chamber 43 through collection port 42. As the apparatus is raised to become aligned with the next segment of interest, the scraper will scrape any lodged ball sealers from the wellbore, which will be similarly collected within the collection chamber. If the operator determines that further scraping within the initially treated segment is necessary, the tool may be raised and lowered in succession to more thoroughly scrape the wellbore segment. This will be particularly effective when an upper scraping member is also present adjacent the upper sealing system.

[0062] Once the apparatus is properly aligned with the next wellbore segment of interest (i.e. with sealing systems 20, 25 straddling the segment), fluid treatment is again initiated to set the sealing members 21, 22, 26, 27 against the wellbore. Delivery of treatment fluid and ball sealers proceeds as above, and is repeated as necessary to similarly treat all segments of the wellbore. Once all treatments are complete, the apparatus is brought to surface and the ball sealers are removed from the collection chamber.

[0063] It is preferable that the lowermost segment of interest within the wellbore is treated first, and that treatment of segments proceeds upwards in succession to maximize sealing and minimize the number of trips downhole.

ALTERNATE EMBODIMENTS

[0064] When only one segment is to be treated, or when it is anticipated that few perforation diverters will be required, the collection chamber may be absent, with diverters collected within a cup-shaped scraper. In situations where diverter collection is not required, the collection chamber may be open at its base or may include a lower discharge port, dropping perforation diverters downhole as necessary.

[0065] If desired, the sealing assemblies may be provided independent from the hydraulic treatment and diversion assembly, and from the scraping and collection assembly. For example, the seals could be appropriately positioned for isolation of each wellbore segment of interest by threading sealing assemblies into a length of tubing at appropriate distances. The scraping and collection assembly may be similarly attached at each interval, or at the bottom of the tubing string, beneath the lowest sealing assembly. The hydraulic treatment and diversion assembly could then be lowered within the tubing to each segment successively for treatment, and when all segments have been isolated and treated, raising the tubing string will cause the entire wellbore to be scraped, and diverters collected.

[0066] With reference to FIG. 4, a proposed alternate embodiment of the invention is shown in which collected perforation diverters may be reused during further fluid treatment. The apparatus is similar to that shown in FIGS. 2 and 3, however, treatment assembly 50 is provided to deliver fluid treatment and diversion, and for scraping and collecting used diverters. Perforation diverters are present within collection chamber 56, and fluid treatment is applied from surface and passes into fluid channel 55, which delivers fluid to the wellbore initially through fluid ports 51. Under higher fluid pressures, treatment fluid will pass into collection chamber 56 with sufficient force to expel diverters from the chamber 56 and into the wellbore through ejection and collection port 52. Diverters will therefore circulate within the isolated wellbore segment during treatment and become lodged within patent perforations to divert treatment to the remainder of the wellbore. Upon termination of fluid treatment, the wellbore is scraped, returning used diverters to the collection chamber 56 via ejection/collection port 52. To facilitate collection, the scraper 41 may be angled to direct balls to port 52. Many other configurations of such a system are possible and will be apparent to those of skill in the art upon reading the present disclosure.

[0067] The above-described embodiments of the present invention are intended to be examples only. Alterations, modifications and variations may be effected to the particular embodiments by those of skill in the art without departing from the scope of the invention, which is defined solely by the claims appended hereto.

What is claimed is:

1. A method for applying hydraulic treatment to a wellbore comprising the steps of:
   reversibly setting hydraulic seals against a wellbore above and below a first wellbore segment of interest to isolate said first wellbore segment:
   delivering hydraulic treatment to the isolated wellbore segment;
delivering perforation diverters to the isolated wellbore segment;
terminating the delivery of hydraulic treatment to the isolated segment;
unsetting the hydraulic seals from the wellbore; and
scraping the wellbore segment to dislodge perforation diverters therefrom.
2. The method as in claim 1 further comprising the step of collecting deployed perforation diverters from the wellbore.
3. The method as in claim 1 wherein the hydraulic seals are packer assemblies.
4. The method as in claim 1 wherein the hydraulic seals are pressure actuated sealing members.
5. The method as in claim 1 wherein the wellbore segment of interest bears two or more perforations.
6. The method as in claim 1 wherein the hydraulic treatment is fracturing fluid, acidizing or energizing treatment, proppants, or cleaning fluid.
7. The apparatus as in claim 6 wherein the hydraulic treatment is in liquid state, gaseous state, or a combination of liquid and gaseous state.
8. The method as in claim 7 wherein the hydraulic treatment further includes solids, waxes, biodegradable, or other particles suspended therewith.
9. The method as in claim 1 wherein the perforation diverters are delivered to the isolated wellbore segment during delivery of the hydraulic treatment fluid.
10. The method as in claim 1 wherein the perforation diverters are ball sealers.
11. The method as in claim 10 wherein the ball sealers are formed from polymeric or elastomeric materials, biodegradable material, ceramics, composites, or wax.
12. The method as in claim 1 wherein the number of perforation diverters deployed within the segment is less than or equal to the number of perforations within the segment.
13. The method as in claim 1 wherein the number of perforation diverters deployed within the segment is greater than the number of perforations within the segment.
14. The method as in claim 1 wherein scraping is performed by abrading the wellbore with a scraper.
15. The method as in claim 14 wherein the perforation diverter is a ball diverter and wherein the scraper is a rigid cup-shaped scraper for dislodging ball diverters from the wellbore.
16. The method as in claim 14 wherein the perforation diverter is gel or foam and wherein the scraper is a wire brush for scrubbing the gel or foam from the wellbore.
17. The method as in claim 14 wherein a diverter collection chamber is operatively attached to the scraper for collecting used perforation diverters from the wellbore segment.
18. The method as in claim 1 further comprising the steps of:
   reversibly setting the hydraulic seals against the wellbore above and below a second wellbore segment of interest to isolate said second wellbore segment;
   applying hydraulic treatment to the isolated second segment;
   deploying perforation diverters within the isolated second segment;
   terminating the application of treatment fluid to the isolated segment;
   unsetting the hydraulic seals from the wellbore; and
   scraping the second wellbore segment to dislodge perforation diverters therefrom.
19. The method as in claim 18 wherein one or more of the perforation diverters deployed within the first isolated segment is collected and then redeployed within the second isolated segment.
20. The method as in claim 18 wherein the first and second segments are within the same wellbore.
21. The method as in claim 18 wherein the first and second segments are within independent wellbores.
22. An apparatus for use in hydraulic treatment of a wellbore, the apparatus comprising:
upper and lower sealing assemblies for reversibly setting at least two hydraulic seals within a wellbore to isolate a portion of the wellbore between the seals;
a hydraulic treatment assembly for applying a hydraulic treatment within the isolated portion of the wellbore;
a diversion assembly operatively attached to the hydraulic treatment assembly for delivering perforation diverters to the isolated portion of the wellbore during hydraulic treatment; and
a scraper assembly for scraping lodged perforation diverters from the wellbore segment.
23. The apparatus as in claim 22 wherein the upper and lower sealing assemblies comprise pressure-activated sealing members for sealing against the wellbore.
24. The apparatus as in claim 22 wherein the scraper assembly includes at least one scraper extending outwardly towards the wellbore to a radial distance less than or equal to the wellbore drift diameter.
25. The apparatus as in claim 22 wherein the scraper is helically disposed about the longitudinal axis of the apparatus.
26. The apparatus as in claim 22 wherein two or more scrapers are arranged radially about the apparatus.
27. The apparatus as in claim 22, further comprising a collection assembly associated with the scraper assembly for collecting deployed perforation diverters within the wellbore.
28. The apparatus as in claim 27 wherein the collection assembly includes a collection chamber having a collection port adjacent the scraper assembly such that scraping action directs used perforation diverters into the collection chamber through the collection port.
29. The apparatus as in claim 28 wherein the hydraulic treatment assembly is continuous with the collection chamber such that when hydraulic treatment fluid is applied to the isolated wellbore segment, at least a portion of the treatment fluid passes through the collection chamber to cause perforation diverters within the collection chamber to be expelled therefrom and delivered to the isolated wellbore segment through the collection port.
30. A diverter scraping and collection assembly for use in removing lodged perforation diverters from a wellbore, the assembly comprising:
a tubular body for suspension within a wellbore;
a scraping member extending radially from the tubular body for scraping a wellbore surface to remove lodged diverters therefrom;
a collection chamber operatively attached to the tubular housing for collecting perforation diverters from the wellbore; and
a diverter collection port adjacent the scraper and continuous with the collection chamber for directing dislodged perforation diverters to the collection chamber.
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