METHOD AND APPARATUS FOR WELL DRILLING AND COMPLETION

Inventors: Mark D. Kalman, Houston, TX (US); Philip D. Nguyen, Duncan, OK (US); Tommy F. Grigsby, Katy, TX (US)

Correspondence Address: Robert A. Kent
2600 South Second Street
Duncan, OK 73520-0440

Appl. No.: 11/450,717
Filed: Jun. 12, 2006

ABSTRACT

Disclosed is a method and apparatus for forming wellbores and in a single trip for also performing multistage wellbore treatments. The disclosed apparatus comprises a bore forming apparatus in the form of a hydraulic drilling motor and bit; a well treatment apparatus in the form of a jetting tool and means for controlling flow to the jetting tool and drilling motor.
METHOD AND APPARATUS FOR WELL DRILLING AND COMPLETION

CROSS-REFERENCE TO RELATED APPLICATION

[001] None

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[002] None

REFERENCE TO MICROFICHE APPENDIX

[003] Not applicable

TECHNICAL FIELD

[004] The present inventions relate generally to well drilling and completion operations and equipment, and more particularly methods and apparatus for performing drilling and multiple stimulation and completion steps in a single trip into the well.

BACKGROUND OF THE INVENTIONS

[005] In some open bore portions of wells it is desirable to individually and selectively create fractures having adequate conductivity at selected locations along the wellbore where it intersects hydrocarbon bearing areas. As used herein, the terms “open bore or open-hole” are defined as and used to refer to a wellbore or portion thereof wherein the walls of the wellbore are not closed off with a tubular member. Open bore section when herein does not refer to a section of a wellbore that is either encased in a tubular or one where the tubular is perforated or slotted.

[006] Multiple treatment steps are typically required along the wellbore where the wellbore intersects one or more hydrocarbon producing areas. In many wells the producing portions of the wellbore are divided into separate locations which are treated in separate steps.

[007] The terms wellbore treatments, formation treatments, and well treatments are used interchangeably to generically refer to any steps performed on the materials (solids and liquids) surrounding the wellbore. These treatment processes include treating the hydrocarbons and waters and hydrocarbon and water bearing deposits in the formations and zones intersecting the wellbore, including, processes of fracturing, perforating and forcing a variety of liquids, solids and mixtures thereof into the material surrounding the wellbore. The materials surrounding the wellbore reached by these treatments can include those adjacent the wellbore as well as those spaced a substantial distance away from the wellbore. Wellbore treatment processes are typically performed to increase the volume of hydrocarbons drained/produced into the wellbore and to reduce the volume of undesirable materials such as sand entering the wellbore.

[008] Traditional methods require using separate trips into the well to perform the steps of drilling a wellbore and of treating a wellbore. These methods are expensive and time consuming.

[009] More recently, Halliburton Energy Services, Inc. has introduced using jetting tools to perform well treatments after a well has been drilled. Jetting tools have at least one jet creating port and are designed to be suspended in the well from a tubular member (such as a coiled tubing) at a treatment location. Fluid or a mixture of fluid and solids are pumped from the surface through port(s) in the tool to form a jet that penetrates the wellbore wall. These jetting tools can be used for well treatments such as perforating, fracturing and for injecting into the material around the wellbore.

[010] The well jetting process is generally referred to by Halliburton as the SURGIFRAC process or stimulation method and is described in U.S. Pat. No. 5,765,642, which is incorporated herein by reference for all purposes. The SURGIFRAC process has been applied to vertical, horizontal or highly deviated wellbores. By using this hydrauljetting technique, it is possible to generate one or more independent fractures; and therefore, highly deviated or horizontal wells can be often completed without having to case the wellbore.

[011] The apparatus invented to perform well treatments with jetting tools includes those disclosed in the above referenced U.S. Pat. No. 5,765,642. Examples of further improvements in the equipment invented by Halliburton Energy Services, Inc. to perform well treatment methods are disclosed in US Patent Application 2005/0263284 entitled Hydrael Perfuration and Fracturing Tool Published Dec. 1, 2005 which is incorporated herein by reference for all purposes. This improved treatment tool includes a jetting tool assembly and a circulation tool assembly with a means for selectively controlling the flow through jetting tool and circulation tool. The particular embodiment of this tool comprises at least one fluid jet port and at least one fluid recirculation port extending through the tool body. The tool further includes a rotating or axially shifting interior sleeve with at least one interior jet port and at least one additional circulation port. Finally, the fracturing tool may include a downhole power unit or other structure capable of changing the orientation of the interior sleeve to align the ports in the body and sleeve to selectively permit flow through the jetting and circulation ports.

[012] Halliburton Energy Services, Inc. has further improved the methods of using jetting tools to perform well treatments, wherein multiple well operations in different locations along the wellbore can be performed on a single trip into the well to reduce the expense and time involved in the operations. Improved methods invented by Halliburton Energy Services, Inc. to perform multiple well treatments in a single trip are disclosed in the US Patent Application #2005/0211439 entitled Method of Isolating Hydrauljet Stimulation Zones published Sep. 19, 2005. Halliburton Energy Services has further improved this process so that it can be performed on a single trip without requiring packers to isolate the well treatment locations. Variations of these new processes offer the opportunity of perforate and stimulate multiple pay zones with a single well intervention often within a single day. The processes employ a hydraulic jetting assembly on coiled tubing (CT) to erode perforations, immediately followed by pumping a fracture-stimulation treatment through the annulus between the CT casing. At the completion of the first fracturing stage, small-volume, high-proppant-concentration slurry is left in the wellbore to provide isolation of the just-stimulated zone from subsequent targets. In some applications, a wellbore screen cut may also be induced to improve the temporary effective isolation of this zone. This sequence (perforate, stimulate, isolate) is repeated until all desired zones have been treated. Following the final stimulation stage, the well is cleaned out with CT and turned over to production. See Packerless Multistage Fracture-Stimulation Method Using CT Perfo-
rating and Annular Path Pumping, SPE paper number 96732, October 2005, Society of Petroleum Engineers, which is incorporated herein by reference for all purposes.

[0013] An example of these improvements comprises first forming (drilling) the wellbore in to a subterranean hydrocarbon bearing area. Following drilling the drilling equipment is removed and a jet treatment assembly is inserted. Wellbore treatment is performed at a first location in the wellbore. For example the wellbore is perforated by injecting a pressurized fluid through a jetting tool into a subterranean location, so as to form one or more perforation tunnels (holes or slots). The injected fluid may or may not contain solid abrasives. Following the perforation step, the material around the wellbore is fractured from the first location by injecting a fracturing fluid (with or without propellant) into the one or more perforation tunnels, so as to create at least one fracture along each of the one or more perforation tunnels. Next, the one or more fractures in the first location are isolated or partially sealed by installing an isolation fluid (or slurry) into the wellbore adjacent to the fractures and/or inside the openings of the fractures. In at least one embodiment, the isolation fluid is a slurry of fracturing fluid and propellant. In another embodiment the isolation fluid has a greater viscosity than the fracturing fluid. Following (or simultaneously with) isolation, the tool is relocated to the next location in the wellbore to be treated. The steps are repeated as required for additional locations. The isolation fluid can be removed from fractures by circulating the fluid out of the fractures, or in the case of higher viscosity fluids, breaking or reducing the fluid chemically or hydrajecting it out of the wellbore.

SUMMARY OF THE INVENTIONS

[0014] The present invention is directed to methods and apparatus for forming and completing all or portions of a wellbore in a single trip and in another aspect a well bore forming and completion process wherein hydrajecting techniques and tools are used. As used herein the term hydrajecting refers to the use of fluid pumped at high rates to create one or more jets to form perforations in the wellbore to induce fracturing around the wellbore and to force fluids into materials surrounding the wellbore. As used herein the term perforation refers to openings penetrating at least through the wellbore wall that is not limited in shape to holes and includes slots and other shaped openings.

[0015] More specifically, the present inventions are directed to methods and apparatus for forming the well bore and completing a well at a subterranean location comprising the following steps: assembling a hydrajecting tool and a bore forming apparatus such as a cutter, (drill bit, mill it), jet drill or the like. Connecting the assembly to a tubular member. Using the drill to form at least a portion of the well to intercept hydrocarbons at one or more subterranean locations. Without removing the drill from the well, using the hydrajecting tool to perform well treatments at one or more axially spaced locations in the wellbore to improve the flow of hydrocarbons into the wellbore and/or to reduce the movement of undesirable materials into the wellbore.

[0016] In another aspect, the present inventions are directed to methods and apparatus for drilling and performing multiple wellbore packerless treatments comprising the following steps. Assembling a downhole well tool assembly comprising a packerless hydrajecting tool and an apparatus such as a drill motor and bit. Connecting the assembly to a tubular member and using the apparatus to form at least a portion of the well to intercept the hydrocarbon bearing subterranean area. Determining well treatment locations. Moving the hydrajecting tool of the assembly into one or more locations along the wellbore to perform well treatments while using materials accumulated in the wellbore to effectively isolate treatment locations. Optionally before exiting the well, the apparatus can be used to clean out the well bore after well bore treatment, using the jetting tool, the well forming apparatus or both.

[0017] An advantage of the present inventions is that the wellbore treatment steps are performed without first removing the drill from the wellbore thus reducing the costs and time required. A further advantage is the provision of a packerless multiple location well treatment process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] A more complete understanding of the present inventions and the advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings in which:

[0019] FIG. 1 is a schematic drawing illustrating a cross section of a wellbore having surface casing and an open bore portion;

[0020] FIG. 2 is a schematic drawing illustrating a cross section of a cased wellbore having and an open bore portion bottom portion;

[0021] FIG. 3 is a schematic drawing illustrating a cross section of a cased wellbore having an open bore branch bore portion;

[0022] FIG. 4 is a schematic drawing illustrating a cross section of a cased wellbore having a lower laterally extending open bore portion;

[0023] FIG. 5 is a longitudinal cross-section of one embodiment of the well forming and completion tool apparatus according to the present inventions; and

[0024] FIGS. 6-12 are cross-sectional views of an open bore portion of a wellbore illustrating the steps of the present inventions.

DETAILED DESCRIPTION

[0025] The details of the methods and apparatus according to the present inventions will now be described with reference to the accompanying drawings wherein like reference characters are used to indicate like or corresponding parts through the several figures.

[0026] FIGS. 1-4 are illustrative of well configurations having at least a wellbore portion 18a of the wellbore 10 intersecting a hydrocarbon bearing subterranean area 20. In these examples, portion 18a of the wellbore intersects a hydrocarbon bearing area. In these examples, portion 18a is to be formed and well treatments performed.

[0027] In FIGS. 1-4 the wellbores 10 extend from a wellhead 12 located at the surface 14 and have an open-hole wellbore 18 and a open hole portion 18a (shown in dotted lines). Portion 18a when completed will intersect a hydrocarbon bearing subterranean area 20. The hydrocarbon bearing area 20 is illustrated as comprising a plurality of separated hydrocarbon bearing portions 20a-20e (arbitrarily illustrated for purposes of description as three separate portions) or area 20 may comprise one continuous hydrocarbon bearing portion. The inventions described herein have particular advantages when area 20 has spaced hydro-
carbon bearing portions each requiring separate well treatments or when the area 20 is one continuous hydrocarbon bearing portion that cannot be ideally treated at a single location.

In the illustrated embodiment of FIG. 1 the wellhead is configured for use with a coiled tubing rig and cementing pumps (not shown). A typical wellhead configuration includes a gooseneck coiled tubing guide 12a, a coiled tubing injector 12b, a stripper 12c, a coiled quad tubing blowout preventer 12d, a double valued dual or quad flow-cross 12e, pipe shear and blind rams 12f. While described herein with respect to a coiled tubing rig, the present inventions can be used with rotary drill rigs.

In FIG. 1 the wellbore 10 has an open bore portion 18 extending from a short casing 16 extending from the surface to a point above the hydrocarbon bearing area 20. In FIG. 2 the wellbore 10 is cased from the surface to a point just above the hydrocarbon bearing area 20. In FIG. 3 the wellbore 10 is cased from the surface to a point below the hydrocarbon bearing area 20 and the casing 16 has a window 30 illustrated located above the area 20. It is envisioned that more than one window could be present in the casing 16 and that any one or more of the windows could be located above, in or below the area 20. In FIG. 4 the wellbore 10 is cased to a point above the hydrocarbon bearing area 20.

The open-bore wellbore portions 18c (shown in dotted lines in FIGS. 1-4) are each to be formed and well treatments performed in accordance with the methods and using the apparatus of the present inventions. In FIGS. 1 and 2 the portions 18c are illustrated as being generally vertical and in FIGS. 3 and 4 the portions 18c are illustrated as being orientated with inclined and horizontally extending portions. Indeed, the present inventions have application in all wellbore orientations and multibore wells.

According to the present inventions one embodiment of the well forming and treatment tool assembly 100 of the present inventions is illustrated in FIG. 5. Tool assembly 100 can be used in a single trip to form a well bore, form extensions of a wellbore and also perform multiple packerless wellbore treatments. These process steps can be performed without removing the tool assembly 100 from the well. The tool assembly is connected to a tubular member 110 and comprises a jetting tool 120, a circulation tool 130, a movable sleeve 140, a down-hole power unit 150, a seat assembly 160; and a drilling assembly 170. In other embodiments the tool assembly may also comprise a measuring while drilling apparatus (MWD) and/or a logging while drilling apparatus (LWD) for performing the additional steps of measuring the properties of the materials (solids and liquids) surrounding the wellbore. As used herein, measuring the properties of the materials surrounding the wellbore is meant to include measurements made by well logging, MWD, LWD and the like.

Well logging is one technique used for measuring and recording rock materials and fluid properties around the wellbore to find hydrocarbon zones in the geological formations below the earth's crust. The prime target of logging is the measurement of various geophysical properties of the subsurface rock formations. Of particular interest is porosity and permeability. A logging procedure consists of moving a "logging tool" through the wellbore (or hole) to measure the rock and fluid properties of the materials surrounding the wellbore. An interpretation of these measurements is then made to locate and quantify potential depth zones containing oil and gas (hydrocarbons). Logging tools measure the electrical, acoustic, radioactive, electromagnetic, and other properties of the rocks and their contained fluids. This data is recorded to a printed record called a "Well Log" which is used with other information to design a well treatment plan. Logging While Drilling (LWD) apparatus, measures geophysical parameters while the well is being drilled and transmit the data via pressure pulses in the well's mud fluid column. The types of instrumentation deployed and measurements made during well logging is quite broad. Logging measurements include the basic electrical logs (resistivity) and spontaneous potential (SP) logs. Porosity is measured (estimated) via sonic velocity and nuclear measurements. Radiofrequency transmission and coupling techniques are used to determine fluid conductivity. Sonic transmission characteristics (pressure waves) determine mechanical integrity. Nuclear magnetic resonance can determine the properties of the hydrogen atoms in the pores (surface tension, etc.). Nuclear scattering (wave scattering), spectrometry and absorption measurements can determine density and elemental analysis or composition. High resolution electrical or acoustical imaging logs are used to visualize the formation, compute formation dip, and analyze thinly-bedded and fractured reservoirs.

MWD is a procedure used to transmit measurements about downhole conditions and orientation in real time, without interrupting the drilling operation. MWD tools are typically used to survey the path of a drilled well, as well as orient a downhole bent mud motor (or bent orienting sub) to drill in a desired direction. Another use of MWD is real time acquisition of natural gamma values.

In the preferred embodiment the tubular member 110 comprises coiled tubing extending through the wellhead 12. While coiled tubing is preferred because of its ease of use and low expense other tubular members could be used such as drill pipe and the like.

The jetting tool 120 is mechanically connected to the tubular member 110 by threads or the like and has an axially extending central passage 128 in fluid communication with the member 110. Passage 128 is defined by an inner wall 122. At least one radial jet passage 125 extends from the jetting tool's inner wall 122 to the jetting tool's outer wall 124. Fluid jet nozzles 126 are present on the outer end of passage 125 for forming directional jets of fluid. Fluid jet nozzles 126 may extend beyond the outer wall 124 or the fluid jet nozzles 126 may extend only to the outer wall 124. In embodiments where fluid jet nozzles 126 extend beyond jetting tool's outer wall 124, the nozzles' orientation may be dependent upon the properties of the materials surrounding the wellbore to be fractured. Fluid jet nozzles 126 have an exterior opening that allows fluid to pass from the passage 128 of jetting tool 120 through passage 125 and through fluid jet nozzles 126 to be directed against the wellbore wall to form perforations therein. Fluid jet nozzles 126 may be composed of any material that is capable of withstanding the stresses associated with fluid fracture and the abrasive nature of the fracturing or other treatment fluid and any propellant or other fracturing agent used. In some jetting tool embodiments, fracturing ports (not shown) can also be provided.

The details of the construction and orientation of a jetting tool example is disclosed in the previously incorporated U.S. Publication 2005/0263284. One of ordinary skill
in the art may vary these parameters to achieve the most effective treatment for the particular well.

[0037] A circulation tool 130 is connected to the jetting tool 120 and has an axially extending central passage 148 in fluid communication with passage 128. In the illustrated embodiment the circulation tool 130 has a cylindrical body with an inner and outer wall. Extending radially from passageway 144 between the circulation tools inner and outer walls is at least one fluid circulation passage 142. For purposes of description the tool 130 is illustrated with four circumferentially spaced longitudinally extending slot shaped passages 142.

[0038] As shown in FIG. 5, a sleeve 140 (that acts as a valve) extends into the passage 128 of jetting tool 120 and into the passage 148 of circulation tool 130. The sleeve 140 is adjacent to the inner wall opening of passages 125 and 142. The sleeve 140 has one or more apertures 132 for each fluid jet passage 125 and one or more apertures 134 for each circulation passage 142. These apertures when properly aligned will allow or prevent fluid to pass through passage 128 to fluid jet nozzles 126 and through circulation passages 142. As will be described below, sleeve 140 can be moved so that the apertures 132 and 134 are in and out of alignment with passages 125 and 142 to selectively and independently block, allow or regulate the flow of fluid through the passages. It is also envisioned that additional apertures in the sleeve 140 could be present for controlling flow through any fracturing ports or a drill motor.

[0039] In the illustrated embodiment, sleeve 140 is designed to move by rotating about a longitudinally extending sleeve axis. By circumferentially spacing the apertures 132 and 134, the sleeve 140 can be rotated so that sets of apertures are aligned or misaligned with one or any combination of passages. Hence, it is possible by controlling the orientation of sleeve 140 to control whether fluid from passage 128 flows through the fluid jet(s), fracturing port(s), or circulation passage(s) or a combination thereof. In one embodiment of the present inventions, it is possible to orient rotating sleeve 140 so as to prevent flow from passage 128 into any one or all of the fluid jets, fracturing ports and circulation passages. It is also envisioned that the sleeve 140 could alternatively be movable axially (or be movable both with rotation and by axial shifting) with axially spaced apertures that shift into and out of alignment with the passages to control flow. It is also envisioned that a plurality of down hole valve units either sleeves or other types could be used to control flow during well treatments instead of the single movable sleeve illustrated.

[0040] Sleeve 140 may be positioned in the desired orientation (rotated or shifted) through any number of methods known in the art. One non-limiting example of a device for re-orienting moving sleeve 140 is by connecting sleeve 140 to downhole power unit 150. Downhole power unit 150 may be any suitable downhole power unit, most often battery powered. Downhole power units are well known in the industry and typically consist of a communication means (e.g., conductor, or communicator); power source (e.g., conductor, battery or compressed gas) and an actuation device (e.g., motor, solenoid or hydraulic cylinder) that is used to operate a downhole tool such as a valve. The downhole power unit 150 may be located above, below or between the jet tool and the circulation tool. The downhole power unit 150 preferably is designed so as to allow fluid flow through an axial fluid passage 152.

[0041] Where downhole power unit 150 is used as the means to move the sleeve 140 into desired orientation, it may be necessary to communicate between surface equip-ment and downhole power unit 150 in order to change orientation. Non-limiting examples of such communications means include mud pulse, sonic, or wireline. Thus, commands and data can be sent between the surface equipment and the downhole power unit 150 to allow control the change of orientation of rotating sleeve 140. Other methods of controlling the sleeve position could for example include mechanically rotating or shifting the sleeve from the surface; using pressure variations in the wellbore to rotate the sleeve and the like, or using a wireline tool directly to move the sleeve either axially or radially.

[0042] Seat assembly 160 is connected to the lower end of the unit 150 and has an axially extending central passage 162 in fluid communication with passage 152. An upwardly facing valve seat 164 is provided in the passage 162 for receiving a ball 166. The ball 166 is inserted into a slot or a hole and flowed or dropped through the tubular member 110 to move to and engage the valve seat to block flow of fluids from the tubular member 110 through the passage 162.

[0043] Drilling assembly 170 is connected to the seat assembly 160. In the illustrated configuration the drilling assembly 170 comprises: a fluid powered motor 172, a drill collar 173, a cutter 174 and a centralizer 180. The cutter 174 is illustrated here as a bit, but it is envisioned that other types of bore forming apparatus could be used instead of a bit and motor combination, such as, devices referred to by different terms including jetting device, cutter, bit, drill, mill and the like.

[0044] The methods and apparatuses of the present inventions are used to perform work on open-hole wellbore portions. The wellbore portions (such as the examples of wellbore portions 18a illustrated as dotted lines in FIGS. 1-4). One advantage of the present inventions is that the steps can be performed not only by using conventional drilling-work over rigs but by using coiled tubing rigs. Further, the methods and apparatus of the present inventions can be used to perform packerless multi-staged well treatments. The steps of using the methods of the present inventions to complete open-hole wellbore portions 18a will be described by reference to FIGS. 6-13. In these figures the wellbore is merely illustrated on the page as being vertical, however the present inventions have application without regard to the orientation of the wellbore.

[0045] According to one example embodiment of the methods of the present inventions, in order to design a well treatment plan to be used on hydrocarbon bearing subterranean area 20, a pilot hole 22 is drilled along the wellbore portions 18a. For example, see FIG. 6 wherein bit 202, drill collar 204 and motor 206 are suspended from coil tubing 110. The pilot hole could also be drilled with a conventional rotating jointed drill string. The pilot hole is smaller in diameter than the ultimate full sized wellbore but of sufficient diameter to allow measurement of the properties of the materials (solids and liquids) surrounding the wellbore, logging or other tests and measurements of the wellbore portions 18a. The resulting data is used to design a well treatment plan for wellbore portions 18a. The treatment plan may involve identifying both the hydrocarbon and water bearing locations along the wellbore. Treatments to perforate fractured and prop locations bearing hydrocarbons and/or plug flow from water bearing areas (also known as conformance treatments may be planned. Conventional pilot hole drilling trip followed by separate open-hole logging equipment trip can be used to perform these steps.

[0046] In a different embodiment, the tools and technology of measuring while drilling (MWD) and/or logging while drilling (LWD) could be used to measure the properties of the materials (solids and liquids) surrounding the
wellbore. In this alternative embodiment, in a single trip into the well the pilot hole is measured and logged while it is drilled. MWD and LWD equipment can be placed in the drill collar 204 or can be in a separate housing. Examples of MWD and LWD processes and equipment are disclosed in U.S. Pat. Nos. 2,810,546; 3,932,836; 3,309,656; 4,254,225; 5,586,084; 6,666,285; 6,859,463; and 6,927,390 which are incorporated herein by reference for all purposes. In the single pilot hole MWD and/or LWD trip data can be obtained for designing a well treatment plan for wellbore portion 18a.

[0047] In another embodiment, MWD and/or LWD equipment could be used during forming of the finished wellbore to measure the properties of the materials (solids and liquids) surrounding the wellbore. MWD and/or LWD equipment could be added to the tool assembly 100 so that data from these measurements used to design a well treatment plan for a wellbore portion is collected during drilling of the finished open wellbore portion 18a. These measurements include all conventional measurements made in well logging and pressure and flow testing. As used herein, the term measuring the material around the wellbore is used in its broadest sense to include any measurements and tests that are useful in locating and designing well treatments for the wellbore. In situations where a pilot hole is unnecessary both the pilot hole drilling trip and separate logging-measuring trip could be eliminated, as described hereinafter in more detail.

[0048] The next step involves, opening up the wellbore portion 18a to a full sized wellbore (See FIG. 7) by using the tool assembly 100. To perform this step the tool assembly 100 illustrated and described with respect to FIG. 5 is assembled, lowered into the wellbore and is used to form a full size wellbore along wellbore portion 18a. As previously described the tool assembly 100 has a drilling assembly 170 comprising a drill collar 173, fluid drill motor 172, cutter 174 and centralizer 180. In this configuration fluid is pumped from the surface into and through tubular member 110, through seat 164, and powers drill motor 172. During drilling, drill fluids and cuttings flow back to the surface by way of the annulus surrounding the tubular member 110. During drilling the fluid jet nozzles 126 and apertures 132 are closed off.

[0049] If the pilot hole trip is eliminated, as previously described, MWD and/or LWD equipment can be included in the drill collar 170 or other portion of the tool assembly 100. The data necessary to design a treatment plan can be collected during drilling and transmitted to the surface without removing the tool assembly 100 from the wellbore. This data may be transmitted by mud pulse, acoustic, laser or electromagnetic telemetry, or for example smart fluids or particles circulated to the surface, or by other methods of downhole to surface communication known to those skilled in the art.

[0050] Once drilling is completed and the wellbore portion 18a is opened up to the desired size for production, well treatment can be performed on the portion. The logging data, either from the pilot hole logging, or the MWD and LWD data obtained during the final hole forming can be used to identify the location of the wellbore portions and type of treatment to be applied to the wellbore portions. In the FIG. 5 embodiment, flow to the drill motor is shut off by pumping a ball 166 onto the seat 164. Ball 166 acts as a check valve when contacting seat 164 blocking flow through the seat and disabling the fluid drill motor. If later need arises to operate the drill, the ball 166 can be dislodged from the seat 164 and returned to the surface by reversing circulation. In another embodiment, seat 164 could be replaced with a valve selectively opened or closed by the DPU 150.

[0051] With the drill motor disabled, wellbore treatments of the wellbore portion 18a may also be accomplished without first removing the tool assembly 100 from the wellbore. The wellbore can be cleaned up by opening passage 142 and pumping cleaning fluids through the well. Formation treatment proceeds as the tool is moved into and out of one or more treatment locations.

[0052] For example the tool assembly 100 can be moved to a first location and perforation can be accomplished by moving the sleeve to open up flow into the at least one fluid jet nozzle 126 and blocking flow through the circulation tool 130. As shown in FIG. 8, with the tool assembly 100 in position, perforation fluid may then be jetted through fluid jet nozzles 126 so as to perforate the wellbore wall. Following perforation, the material surrounding the wellbore may be fractured by increasing the rate of fluid pumped from fluid jet nozzles 126. The pressure of the fluid which is jetted through fluid jet nozzles 126 is raised until it reaches the jetting pressure sufficient to cause the creation of the cavities or fractures 250. Fractures may also be created by pumping fluid down the annulus. Pumping fluids (or fluids mixed with solids) through the annulus allows increased flow rates of fracturing fluids above the flow rate allowable through the jetting nozzles. Prior to this step treating of the material surrounding the wellbore can be performed. By maintaining the proper pressure differential between the annulus and tubing, the ball 166 can be maintained on the seat 164, in the pump down ball embodiment. For example, the material around the wellbore can be consolidated by pumping and or jetting a curable resin into material and allowing it to harden to form a porous mass around the wellbore. Treatments, such as, consolidation can comprise multiple steps of pumping treatment fluids including pre-flush, spacers, curable resin, curing agent, post-flush, followed by pumping other chemicals.

[0053] A variety of fluids can be utilized in accordance with the present inventions for forming fractures, including aqueous fluids, viscousified fluids, oil based fluids, and even certain “non-damaging” drilling fluids known in the art. Various additives can also be included in the fluids utilized such as abrasives, fracture propping agent, e.g., sand or artificial proppants, acid to dissolve subterranean materials and other additives known to those skilled in the art. Conformance fluids which prevent flow from water producing areas or relative permeability modifiers, which reduce water flow from commingled areas may also be injected into the materials surrounding the wellbore.

[0054] As is well known the pressure at which the fluid must be jetted from fluid jet nozzles 126 and/or pumped from the annulus to result in the fractures 250 is dependent upon the particular type of rock and/or other materials surrounding the wellbore and other factors known to those skilled in the art. Generally, after a wellbore is drilled, the fracture initiation pressure can be determined based on information gained from testing and logging and during drilling and other known information.

[0055] Depending upon the formation treatment plan, a propping agent or other solid may be combined with the fluid being jetted into the material surrounding the wellbore. The propping agent, e.g., sand, resin coated sand or the like functions to prop open the fractures 250 when they attempt to close as a result of the termination of the fracturing process. Some propping agents also stabilize the material surrounding the wellbore and act as a filter to keep undesirable materials from flowing into the wellbore.
While propping agent 260 can be mixed at the surface with the jetting fluid in the preferred embodiment it is pumped down the annulus. As illustrated in FIG. 9 propping agent 260 in slurry form is pumped down the wellbore into the annulus surrounding the tool assembly 100. Fluids are pumped down the tubular member 110 at a sufficient rate so that with the assistance of the jetting tool to force the propping agent into the fractures 250. In order to insure that the propping agent remains in the fractures when they close, the jetting proppant slurry pumping pressures are preferably slowly reduced to allow fractures 250 to close on propping agent. In addition, the propping agent 260 is held in fractures 250 by the fluid jetting during the closure process. During this process propping agent 260 accumulates in the wellbore at or above the first treatment location.

Before moving the tool assembly 100 to a new location additional well treatment processes can be performed such as pumping fluids into the propping agent and material surrounding the wellbore. For example, acids, stabilizers, tackifiers, curable resin, and the like could be pumped. If an uncoated proppant is used a curable resin could be pumped into the proppant to consolidate the proppant pack for proppant flowback control.

Following completion of well treatment at the first location the tool assembly can be moved uphill to a point above the next treatment location or above the excess propping agent 260 in the wellbore. As used herein, uphill refers to the direction along the wellbore toward the wellhead and may include lateral or downward movement as well as vertically upward movement. To eliminate any proppant or other material bridging the wellbore, the tool can be washed down to the next treatment location to clear the wellbore, as shown in FIG. 11. To accomplish this clean out step the circulation tool is opened and fluid pumped through the tool assembly 100 and up the annulus to remove any debris or propping agent to allow the tool to move down to the next treatment location. Well bore clean out can also be accomplished by operating the drill assembly to ream out the wellbore. The clean out step can be eliminated if the wellbore is unobstructed at the next treatment location. For example, if settable resin coated proppant has been used in the treating step and the resin has hardened in the wellbore, then clearing of the wellbore to the next treatment location can be accomplished by using the drilling assembly to ream out the wellbore. Reaming out can be performed with or without washing down the wellbore.

The well treatment process can be completed at the new location as shown in FIG. 12 without requiring the use of a packer or bridge plug. In this process the proppant material in the wellbore above the first treatment location acts as a sand bridge or sand plug effectively isolating or sealing off the first treatment area. Isolation can also be accomplished by installing an isolation fluid into the wellbore adjacent to the fractures and/or inside the openings of the fractures. In at least one embodiment, the isolation fluid is a slurry of fracturing fluid and proppant. In another embodiment the isolation fluid has a greater viscosity than the fracturing fluid. This “packerless” multiple stage well treatment process provides advantages and eliminates the difficulties and problems and trips into the well associated with installing and/or setting and removing and/or unsettring packers, frac plugs, bridge plugs and the like.

The multiple well treatment process can be performed in a single trip (without removing the well tool assembly 100 from the well) by moving up the well from treatment location to treatment location and repeating the appropriate processes described above. Once all necessary well treatments are completed the wellbore can be cleaned of propping agent before removing the tool assembly by opening the circulation ports or by a separate cleanout trip using coil tubing. Cleaning can also be accomplished after each zonal treatment by opening the circulation ports and circulating fluid through the string and annulus. As previously mentioned, the wellbore clean out step can be accomplished by using the wellbore forming apparatus either alone or in conjunction with fluid flow. For example, if cured resin coated proppant is present in the wellbore following wellbore treatment, the drilling and treatment assembly can be used to ream out the wellbore without removing the assembly from the wellbore. To accomplish this step, the DPU would be operated to open the valve (or sleeve valve) controlling fluid flow to the drill motor, the drill would be operated and advanced back through the wellbore to ream out the cured resin. This reaming out could be performed with washing fluid flowing from the circulation tool 130 and or fluid nozzles. Indeed, an open bore completion without screens or gravel packing can be achieved in a single trip using these inventions with resin coated proppant and wellbore remount. Upon completion of the treatment, a production tubing assembly may or may not be placed into the open hole portion of the wellbore. The production tubing assembly may include a slotted or perforated expandable or non-expandable liner, and either non-expandable or expandable screens, expandable, swellable or conventional hydraulic or mechanical force setting packers to isolate portions of the wellbore. Gravel packing may also be considered in portions of the wellbore if necessary to prevent sand production.

Therefore, the present inventions are well-adapted to carry out the objects and attain the ends and advantages mentioned as well as those which are inherent therein. While the invention has been depicted, described, and is defined by reference to exemplary embodiments of the invention, such a reference does not imply a limitation on the invention, and no such limitation is to be inferred. The invention is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those ordinarily skilled in the pertinent arts and having the benefit of this disclosure. The depicted and described embodiments of the invention are exemplary only, and are not exhaustive of the scope of the invention. Consequently, the invention is intended to be limited only by the spirit and scope of the appended claims, giving full cognizance to equivalents in all respects.

1. A method for forming and treating at least a portion of a wellbore comprising the steps of:
   assembling a tool comprising a wellbore forming assembly and a wellbore treating assembly;
   connecting the tool to a tubular member;
   inserting the tool into the wellbore; and
   without removing the tool from the wellbore, extending the wellbore with the wellbore forming assembly and performing more than one well treatment of the material surrounding the wellbore with the wellbore treating assembly;
   wherein the step of performing more than one well treatment comprises: performing a well treatment step at one location: moving the tool to at least another axially-spaced location and performing an additional well treatment step; and, without the use of packer or bridge plug, effectively isolating the wellbore at the one location from the wellbore at the another location after
completing the well treatment step at one location and before the well treatment step at another location.

2. (cancelled)

3. (cancelled)

4. The method of claim 2 for forming and treating at least a portion of a wellbore wherein the well treatment steps comprise forming one or more fractures in the material surrounding the wellbore at the at least at two spaced locations along the wellbore portion.

5. The method of claim 4 for forming and treating at least a portion of a wellbore wherein the fracturing steps comprise pumping fracturing fluid into the wellbore.

6. The method of claim 4 for forming and treating at least a portion of a wellbore wherein the fracturing steps comprise first forming perforations in the wellbore wall and then pumping fracturing fluid into the wellbore.

7. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the step of isolating comprises installing an isolation fluid in the wellbore adjacent to the one location.

8. The method of claim 7 for forming and treating at least a portion of a wellbore wherein the isolation fluid is slurry of fracturing fluid and proppant.

9. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the well treatment steps comprise perforating the wellbore wall.

10. The method of claim 9 for forming and treating at least a portion of a wellbore wherein the wellbore treatment assembly comprises at least one fluid nozzle and wherein the perforating step comprises pumping fluids through the nozzle to contact the wellbore wall.

11. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the step of performing more than one well treatment additionally comprises causing one or more fractures to form in the material surrounding the wellbore at the one location, isolating the one location from the another location and then causing one or more fractures to form in the material surrounding the wellbore at the another location.

12. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the step of performing more than one well treatment step comprises pumping liquids from the wellbore into the materials surrounding the wellbore.

13. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the wellbore extending step comprises rotating and axially advancing a cutter to extend the wellbore.

14. The method of claim 1 for forming and treating at least a portion of a wellbore wherein the wellbore extending step comprises following the path of a pilot hole.

15. The method of claim 2 for forming and treating at least a portion of a wellbore additionally comprising the step of cleaning out at least a portion of the wellbore following the well treatment steps and without removing the tool from the wellbore.

16. The method of claim 15 for forming and treating at least a portion of a wellbore wherein the cleaning out step comprises using the well forming assembly.

17. The method of claim 15 for forming and treating at least a portion of a wellbore wherein the cleaning out step comprises reaming out a portion of the wellbore.

18. The method of claim 1 for forming and treating at least a portion of a wellbore additionally comprising measuring the properties of the materials surrounding at least a portion of the wellbore without removing the tool from the wellbore.

19. The method of claim 18 for forming and treating at least a portion of a wellbore wherein the step of measuring the properties of the materials surrounding the wellbore comprises logging the at least a portion of the wellbore.

20. The method of claim 18 for forming and treating at least a portion of a wellbore wherein the step of measuring the properties of the materials surrounding the wellbore comprises logging while drilling the at least a portion of the wellbore.

21. The method of claim 18 for forming and treating at least a portion of a wellbore wherein the step of measuring the properties of the materials surrounding the wellbore comprises measuring while drilling the at least a portion of the wellbore.

22-29. (cancelled)

30. A method for forming and treating at least a portion of a wellbore comprising the steps of:
   assembling a tool comprising a wellbore forming assembly and a wellbore treating assembly;
   connecting the tool to a tubular member;
   inserting the tool into the wellbore; and
   without removing the tool from the wellbore, extending the wellbore with the wellbore forming assembly and performing more than one well treatment of the material surrounding the wellbore wherein the step of performing more than one well treatment comprises causing one or more fractures to form in the material surrounding the wellbore at the one location, isolating the one location from the another location, and then causing one or more fractures to form in the material surrounding the wellbore at the another location.

31. The method of claim 30 for forming and treating at least a portion of a wellbore wherein the step of isolating comprises installing an isolation fluid in the wellbore adjacent to the one location.

32. The method of claim 31 for forming and treating at least a portion of a wellbore wherein the isolation fluid is slurry of fracturing fluid and proppant.

33. The method of claim 30 for forming and treating at least a portion of a wellbore wherein the step of isolating is performed without the use of a packer or bridge plug.

34. A method for forming and treating at least a portion of a wellbore comprising the steps of:
   assembling a tool comprising a wellbore forming assembly and a wellbore treating assembly;
   connecting the tool to a tubular member;
   inserting the tool into the wellbore; and
   without removing the tool from the wellbore, extending the wellbore with the wellbore forming assembly and performing more than one well treatment of the material surrounding the wellbore; wherein the step of performing more than one well treatment comprises performing a well treatment at one location; and moving the tool to at least another axially-spaced location and performing an additional well treatment; cleaning out at least a portion of the wellbore following the step of performing more than one well treatment and without removing the tool from the wellbore; and
measuring the properties of the materials surrounding at least a portion of the wellbore without removing the tool from the wellbore.

35. The method of claim 34 for forming and treating at least a portion of a wellbore wherein the cleaning out step comprises using the wellbore forming assembly.

36. The method of claim 34 for forming and treating at least a portion of a wellbore wherein the cleaning out step comprises reaming out a portion of the wellbore.

37. The method of claim 34 for forming and treating at least a portion of a wellbore additionally comprising the step of, without the use of a packer or bridge plug, effectively isolating the wellbore at the one location from the wellbore at the another location after completion of the well treatment at the one location and before well treatment at the another location.

* * * * *