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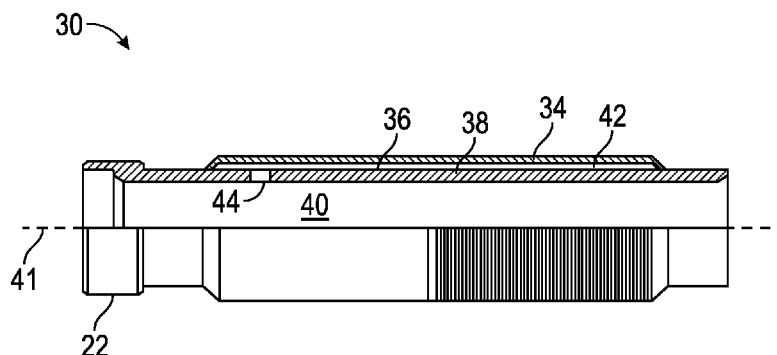


FIG. 2

(57) **Abstract:** A technique facilitates control over fluid flow with respect to a sand screen assembly. The sand screen assembly may comprise a base pipe, a sand screen disposed about the base pipe, and an inflow control device assembly. The inflow control device assembly comprises an inflow control device combined with a check valve in fluid communication with the inflow control device. The check valve is oriented to block fluid flow through the inflow control device in a given direction. Additionally, the inflow control device may be in the form of an autonomous inflow control device to provide different levels of flow control depending on a property or properties of the fluid.



PATENT APPLICATION**SYSTEM AND METHODOLOGY UTILIZING INFLOW CONTROL DEVICE
ASSEMBLY****CROSS-REFERENCE TO RELATED APPLICATION**

[0001] The present document is based on and claims priority to U.S. Provisional Application Serial No.: 62/221385, filed September 21, 2016, which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] When well fluid is produced from a subterranean formation, the well fluid may contain particulates often referred to as sand. The production of sand from the well is sometimes controlled to prevent erosion and to protect well string equipment. One approach for controlling sand production is to install sand screens in the well to filter sand from the produced well fluid. Various types of sand screens may be used such as sand screens formed from cylindrical mesh or sand screens formed by wrapping wire in a helical pattern. The sand screen may be part of a larger sand screen assembly having at least one sand screen, a base pipe that forms part of the tubing string, and at least one inflow control device. Inflow control devices regulate the flow of produced fluid into an interior space of the base pipe.

SUMMARY

[0003] In general, a system and methodology facilitate control over fluid flow with respect to a sand screen assembly. The sand screen assembly may comprise a base

pipe, a sand screen disposed about the base pipe, and an inflow control device assembly. The inflow control device assembly comprises an inflow control device combined with a check valve in fluid communication with the inflow control device. The check valve is oriented to block fluid flow through the inflow control device in a given direction. For example, the check valve may be oriented to block flow moving in a direction from an interior of the base pipe to an exterior of the sand screen assembly or from the exterior of the sand screen assembly to the interior of the base pipe. Additionally, the inflow control device may be in the form of an autonomous inflow control device to provide different levels of flow control depending on a property or properties of the fluid.

[0004] However, many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Certain embodiments of the disclosure will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements. It should be understood, however, that the accompanying figures illustrate the various implementations described herein and are not meant to limit the scope of various technologies described herein, and:

[0006] Figure 1 is an illustration of an example of a completion string deployed in a borehole, e.g. a wellbore, according to an embodiment of the disclosure;

[0007] Figure 2 is a partial cross-sectional view of an example of a sand screen assembly which may be disposed at a suitable location along the completion string, according to an embodiment of the disclosure;

[0008] Figure 3 is an illustration of an example of an inflow control device assembly which may be employed in the sand screen assembly, according to an embodiment of the disclosure;

[0009] Figure 4 is another view of the inflow control device assembly illustrated in Figure 3, according to an embodiment of the disclosure;

[0010] Figure 5 is an illustration of another embodiment of an inflow control device assembly, according to an embodiment of the disclosure;

[0011] Figure 6 is an illustration of another embodiment of an inflow control device assembly, according to an embodiment of the disclosure;

[0012] Figure 7 is an illustration of another embodiment of an inflow control device assembly coupled to a base pipe of a sand screen assembly, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0013] In the following description, numerous details are set forth to provide an understanding of some embodiments of the present disclosure. However, it will be understood by those of ordinary skill in the art that the system and/or methodology may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0014] The present disclosure generally relates to a system and methodology which facilitate control over fluid flow with respect to a sand screen assembly. The sand screen assembly may be coupled into a well completion string deployed in a borehole, e.g. a wellbore. In various applications, a plurality of the sand screen assemblies may be combined into the well completion string to filter and control flow of fluid from or to a plurality of surrounding well zones.

[0015] By way of example, each sand screen assembly may comprise a base pipe, a sand screen disposed about the base pipe, and an inflow control device assembly. The sand screen may comprise a mesh sand screen, a wire wrapped sand screen, a perforated sheet, or another suitable type of sand screen. Additionally, the sand screen may comprise a single screen section or a plurality of screen sections. The inflow control device assembly may comprise an inflow control device (ICD) combined with a check valve in fluid communication with the inflow control device. For example, the inflow control device may be positioned in series with the check valve. The check valve is oriented to block fluid flow through the inflow control device in a given direction. For example, the check valve may be oriented to block flow moving in a direction from an interior of the base pipe to an exterior of the sand screen assembly or from the exterior of the sand screen assembly to the interior of the base pipe. Some sand screen assemblies may comprise a plurality of the inflow control device assemblies.

[0016] In some embodiments, each inflow control device may be in the form of an autonomous inflow control device (AICD) to provide different levels of flow control depending on a property or properties of the fluid. Depending on the characteristics of a given well operation, the autonomous inflow control device may have a variety of structures to control, for example, the rate of fluid flow through the inflow control device assembly based on a specific property of the fluid, e.g. viscosity or density of the fluid. Examples of autonomous inflow control devices are provided in, for example, US Patent Application Publication No.: 2015/0060084, which is hereby incorporated by reference as if fully set forth herein.

[0017] As described in greater detail below, certain embodiments of the inflow control device assemblies combine an autonomous inflow control device with a check valve for use in production and/or injection operations in a wellbore. The combination of the autonomous inflow control device with the check valve provides a desired control over fluid flow while enabling the well system to be run downhole without a wash pipe. During a wellbore operation, the combined autonomous inflow control device and check

valve may be used to allow inflow of well fluids while blocking outflow from an interior of the corresponding base pipe. As well fluids are pumped through the base pipe in which the autonomous inflow control devices installed, the check valve prevents those fluids from flowing outwardly through openings in the wall of the base pipe and the autonomous inflow control device into the surrounding wellbore. This ensures that the pumped fluid enters and exits the base pipe at the desired ingress and egress points.

[0018] Referring generally to Figure 1, an embodiment of a well system 20 is illustrated. In this example, the well system 20 comprises a well string 22, e.g. a tubular completion string, deployed in a borehole 24, e.g. a wellbore. In a variety of well applications, the wellbore 24 may extend through a geologic formation 26 or a plurality of formations 26. Additionally, the wellbore 24 may be cased or uncased in accordance with the corresponding well operation. In some implementations, the wellbore 24 may be deviated, e.g. horizontal, and may be part of a subterranean or subsea well.

[0019] In multizone implementations, the completion string 22 may extend along wellbore 24 through an isolated well zone or zones 28 to facilitate production of well fluid or injection of fluids at the desired well zone or zones 28. The completion string 22 may comprise at least one sand screen assembly 30. In the embodiment illustrated, the completion string 22 comprises a plurality of sand screen assemblies 30 disposed in corresponding well zones 28. The sand screen assemblies 30 may be used to regulate the injection of fluid from a central passageway of the completion string 22 into a surrounding annulus 32 or to regulate the production of well fluid from the annulus 32 into the central passageway of the completion string 22.

[0020] The completion string 22 also may comprise packers 33 which may be radially expanded and set to seal off sections of annulus 32 which correspond with well zones 28. In Figure 1, the packers 33 are illustrated in their unset or radially contracted states which enables deployment of the completion string 22 downhole into wellbore 24. Throughout the description herein, the well string 22 may be described as receiving produced well fluid, however it should be understood that the well string 22 also may be

used for injection operations in which fluid is injected from the well string 22 into the surrounding well zones 28.

[0021] With additional reference to Figure 2, each sand screen assembly 30 may comprise a sand screen 34 mounted about a base pipe 36. The base pipe 36 may have a tubular wall 38 defining an internal, central passage 40 through which production fluids may flow to a desired collection location, e.g. a collection location at the surface of the earth. In injection operations, the injection fluid may be pumped down through the internal passage 40 for injection into the desired well zones 28. According to an embodiment, the base pipe 36 may be concentric about a longitudinal axis 41 and may extend along the tubular completion string 22. By way of example, the sand screen 34 may circumscribe the base pipe 36 to form a fluid receiving region 42, e.g. an annular fluid receiving region, between an outer surface of the base pipe 36 and an interior surface of the sand screen 34.

[0022] Each sand screen assembly 30 further comprises a flow controller 44 which may be in the form of an inflow control device assembly. The inflow control device assembly 44 controls the flow of a fluid through a radial opening or openings in wall 38 of base pipe 36. Thus, fluid flow is controlled between an exterior of sand screen assembly 30, e.g. annulus 32, and an interior of the base pipe 36, e.g. internal passage 40. The inflow control device assembly 44 may be constructed to control flow from annulus 32 into internal passage 40 and/or to control flow of fluid from internal passage 40 to annulus 32.

[0023] It should be noted the sand screen assembly 30 illustrated in Figure 2 is provided as an example, and the sand screen assembly 30 may have various other constructions and implementations. According to another embodiment, the region outside of the sand screen assembly 30, e.g. annulus 32, may be gravel packed. In some embodiments, the sand screen assembly 30 may comprise a sleeve valve which may be selectively opened and/or closed to facilitate a gravel packing operation. Additional

and/or other components and features of the sand screen assembly 30 may be selected according to the parameters of a given operation.

[0024] Referring generally to Figures 3 and 4, an embodiment of inflow control device assembly 44 is illustrated as comprising an inflow control device 46 and a check valve 48 (see Figure 4). The check valve 48 is in fluid communication with the inflow control device 46 and is operatively coupled with the inflow control device 46 to block fluid flow through the inflow control device 46 in a given direction while allowing flow in the other direction. The inflow control device assembly 44 may be disposed in whole or in part within an opening in wall 38 of base pipe 36. In some embodiments, the inflow control device assembly 44 may be positioned in whole or in part in a related component, such as a ring or annular housing mounted about the base pipe 36, as described below with reference to Figure 7.

[0025] The inflow control device assembly 44 may be used in, for example, downhole production sections such as sand screen assembly 30. Inflow control device assemblies 44 may be used to regulate production so that a producing reservoir is generally uniformly depleted. During oil production, the pressure distribution inside the completion string 22 may not be uniform due to internal frictional losses within the tubing, e.g. base pipe 36, and due to varying flow rates at different sections of the tubing. Additionally, formation permeabilities may vary substantially from well zone to well zone and this can have a substantial effect on the well fluid production rate. The inflow control device assemblies 44 may be used to control, e.g. regulate, the inflow of fluid at each well zone 28 so as to help ensure uniform depletion of the reservoir.

[0026] By way of further example, a lateral or horizontal wellbore such as the wellbore 24 illustrated in Figure 1 may have a heel section and a toe section subject to different differential pressures and depletion rates. The heel section of the completion string 22 may have an associated higher differential pressure and associated faster depletion rate relative to the toe section, thus giving rise to a “heel-to-toe” effect which can be detrimental to overall production. During oil production, a change in an oil/water

interface and/or an oil/gas interface may result in “coning” which can lead to premature breakthrough of unwanted fluids such as gas or water. The inflow control device assemblies 44 may be used to help balance the pressures and flow rates to reduce “heel-to-toe” effects, coning effects, and other detrimental effects with respect to production and depletion of a given reservoir.

[0027] Gas and water can play useful roles when left in place. For example, gas can serve as a driver to displace oil in the formation 26 due to its relatively higher compressibility and thus its relatively higher stored energy. Water can serve to lift the oil and may sometimes be produced with the oil. The inflow control device assemblies 44 may be used to control the water and gas production to ensure a greater amount of the gas and water remain in the formation 26. The inflow control device assemblies 44 may be used to inhibit gas or water production to a certain degree depending on dimensional parameters of the components of each inflow control device assembly 44. Consequently, the inflow control device assemblies 44 may be selected to provide a desired regulation with respect to the production of water and/or gas.

[0028] Without use of the inflow control device assemblies 44, water and gases can begin to dominate the volume fraction of the produced mixture of well fluids. Because water has a relatively lower viscosity and gases have relatively lower viscosities and densities, these fluids may flow through the formation 26 with relatively lower resistance compared to oil. If substantial water and gas are produced, an additional burden is placed on above-ground separators and recycling systems and can lead to premature abandonment of partially depleted reservoirs. The premature abandonment can leave a substantial amount of oil, e.g. a majority of the oil, near the completion unproduced, thus adversely affecting profitability.

[0029] According to embodiments described herein, the inflow control device assemblies 44 may comprise inflow control devices 46 in the form of autonomous inflow control devices 46. Consequently, the inflow control device 46 of each corresponding inflow control device assembly 44 may autonomously respond differently depending on

at least one property of the fluid flowing through the inflow control device assembly 44. For example, the autonomous inflow control device 46 may be selected to respond differently to different fluids based on a given fluid property or properties, e.g. viscosity, density, flowrate, or other properties. The inflow control device 46 may be selected, for example, to undergo a relatively larger flow resistance and a relatively larger pressure drop for an “undesirable” fluid, such as gas or water. However, the same inflow control device 46 provides relatively lower flow resistance and relatively lower pressure drop for a “desirable” fluid, such as light oil or heavy oil. The potential well fluids that may be produced tend to vary in composition and have different associated Reynolds numbers so that selection of appropriate inflow control devices 46 can be used to autonomously control the mixture of fluid moving through each inflow control device assembly 44.

[0030] The Reynolds number is a function of fluid properties, such as viscosity, density, and flowrate. The desired fluid, e.g. oil, has one set of fluid properties, e.g. a given viscosity and density or a known range of viscosities and densities, as compared to the different viscosities and densities associated with undesirable fluids, e.g. water and/or gas. For a given flowrate, these fluid property differences between desirable and undesirable fluids result in different corresponding Reynolds numbers and consequently differences in the corresponding flow behaviors through the inflow control device assemblies 44.

[0031] It should be noted that whether a particular fluid is considered desirable or undesirable depends on the particular application. By way of example, each inflow control device assembly 44 may be constructed for use in production of light oil when there is potential for a gas breakthrough problem. In this example, the light oil is the desirable fluid and the gas is the undesirable fluid. In another example, each inflow control device assembly 44 may be constructed for use in production of heavy oil when there is the potential for high water cut. In this example, the heavy oil is the desirable fluid in the water is the undesirable fluid. Each inflow control device assembly 44 also may be constructed for use in the production of light oil when there is a potential for high

water cut. In this example, the light oil is the desirable fluid in the water is the undesirable fluid.

[0032] For each of these examples, the desirable fluid has a relatively higher viscosity. In some cases, however, the desired fluid may have a lower viscosity. In a gas well example, for example, it may be desirable to prevent water breakthrough in the gas well. In this example, the gas has a relatively lower viscosity and is the desirable fluid while the water has a relatively higher viscosity and is the undesirable fluid.

[0033] The inflow control device assembly or assemblies 44 may be constructed for use in a variety of environments and operations. Generally, each inflow control device assembly 44 provides a more favorable pressure versus flowrate characteristic for a desirable fluid which is to be produced as compared to the pressure versus flowrate characteristics for a less desirable fluid. In some applications, the autonomous inflow control device 46 of each assembly 44 may be constructed to form a vortex inducer which creates jets from the incoming fluid flow and directs these jets into a flow chamber of the inflow control device 46 (see Figures 3-6). Inside the flow chamber, the jets create a rotational flow as well as an axial flow that translates toward an outlet of the chamber which serves as a discharge for the inflow control device 46. The induced rotational flow results in a pressure drop, and the extent of the pressure drop is a function of the fluid composition, e.g. fluid properties, of the flow, thus providing an autonomous inflow control device.

[0034] Referring again to the axial cross-section of Figure 3 and longitudinal cross-section of 4, an example of such an autonomous inflow control device 46 is illustrated. In this example, the inflow control device 46 has a generally frustoconical-shaped chamber 50 formed inside a housing 52 of the inflow control device 46. The frustoconical-shaped chamber 50 extends generally along a longitudinal axis 54 of the inflow control device 46. Additionally, the inflow control device 46 may comprise an inlet 56 or a plurality of inlets 56 which direct generally tangential jets, as represented by

arrows 58, into the chamber 50. In the specific example illustrated, two inlets 56 are oriented to direct tangential jets 58 into chamber 50.

[0035] In this embodiment, the frustoconical chamber 50 extends along longitudinal axis 54 from a transverse base wall 60 (see Figure 4) which may be orthogonal to axis 54 and located generally proximate inlets 56. The chamber 50 extends to a discharge or outlet 62 located at an opposite end of the frustoconical chamber 50. By way of example, the check valve 48 may be positioned proximate outlet 62. In this example, the inlets 56 are oriented to inject tangential jets 58 into chamber 50 at an end of the chamber 50 associated with transverse base wall 60. In some embodiments, the outlet 62 may be generally coaxial with the longitudinal axis 54, and the chamber 50 may be generally symmetric about the axis 54.

[0036] The orientation of inlets 56 causes jets 58 to be directed tangentially along the wall defining chamber 50. In other words, the jets 58 are directed along tangents of a circle associated with a perimeter of the base wall 60. The jets 58 generally correspond to tangents of a circle for which the inlets 56 may be considered points that are on or near the circle. In some embodiments, the inlets 56 may be oriented to direct the jets 58 in directions that are directly opposed to each other. In some embodiments, the inlets 56 may be oriented to direct jets 58 in directions that are neither tangential nor directly opposed but rather somewhere in between, e.g. orientations in which jets 58 are closer to being tangential than to being directly opposed. Regardless of the specific orientations of inlets 56, the inlets 56 introduce jets 58 into frustoconical chamber 50 in a manner such that interaction of the jets 58 with the wall defining chamber 50 produces a flow that rotates and translates in a direction toward the outlet 62 of the inflow control device 46. The induced flow pattern causes, for example, a pressure drop and the extent of the pressure drop is a function of the fluid composition, e.g. fluid properties, thus providing an autonomous inflow control device.

[0037] As illustrated in Figure 4, chamber 50 may be defined at least in part by a tapered wall section 64 which causes the chamber 50 to progressively narrow in a

direction from the base wall 60 to the outlet 62. The chamber 50 may have a larger diameter, circularly cylindrical section 66 extending from base wall 60 to tapered wall section 64 thus providing space for inlets 56. By way of example, the chamber 50 also may comprise a smaller diameter circularly cylindrical section 68 proximate outlet 62. The particular shapes of the cylindrical and/or tapered sections 64, 66, 68 may vary in length and diameter and may have other forms suitable for a given application. Additionally, the angle of tapered wall section 64 may vary depending on the given application. The radial distance between inlets 56 and the size of inlets 56 also may vary. In some applications, a single inlet 56 or more than two inlets 56 may be provided.

[0038] Characteristics of the wall defining frustoconical chamber 50 also may vary. In the illustrated example, the wall defining chamber 50 is smooth which can be useful for minimizing flow turbulence. However, the inflow control device 46 may have additional features within chamber 50 to, for example, enhance aspects of the rotational flow and/or to increase pressure loss associated with the rotational flow. By way of example, at least one structure may be positioned to extend from or to be recessed within the wall defining chamber 50.

[0039] Referring generally to Figure 5, another embodiment of inflow control device assembly 44 is illustrated as having check valve 48 coupled with an autonomous inflow control device 46. In this embodiment, the autonomous inflow control device 46 is positioned in series with the check valve 48, and the check valve 48 is located proximate outlet 62 of inflow control device 46. The check valve 48 may be connected directly to the autonomous inflow control device 46 or it may be spaced apart but in fluid communication with the autonomous inflow control device 46.

[0040] In this example, the autonomous inflow control device 46 again comprises at least one inlet 56 directing fluid flow into chamber 50 which may be in the form of a frustoconical chamber. The fluid, e.g. well fluid, flows through inlet 56 from fluid receiving region 42 of sand screen assembly 30 and then moves through chamber 50 until

exiting at outlet 62. The check valve 48 has a check valve inlet 70, a check valve outlet 72, and a one-way flow control member 74 positioned between inlet 70 and outlet 72.

[0041] In the specific example illustrated, the one-way flow control member 74 is in the form of a check valve ball 76 disposed between inlet 70 and outlet 72. The check valve ball 76 may be located adjacent a valve seat 78 which cooperates with the ball 76 to block flow of fluid when the flow of fluid moves the ball 76 against valve seat 78. In other words, fluid flow in a direction from check valve outlet 72 toward check valve inlet 70 is blocked and the fluid is prevented from moving into outlet 62 of inflow control device 46. However, the ball 76 is moved away from valve seat 78 when fluid flows in the opposite direction from outlet 62, through check valve inlet 70, past ball 76, and out through check valve outlet 72.

[0042] The one-way flow control member 74, e.g. check valve ball 76, may be retained between inlet 70 and outlet 72 within a check valve housing 80 via a retainer member 82. The retaining member 82 may be in the form of a mesh, cage, insert, reduced size opening, or other structure which allows fluid flow through check valve outlet 72 while preventing ball 76 from exiting the check valve outlet 72.

[0043] In some embodiments, the check valve 48 may be permanently disabled by dissolving or degrading some portion of the check valve 48. For example, the check valve may be dissolved or otherwise degraded via chemical reaction or other suitable technique to allow unimpeded flow through outlet 62 following completion of a specific downhole operation. By way of example, the ball 76, retaining member 82, or check valve housing 80 may be constructed from a material which may be degraded to enable the unimpeded flow.

[0044] Referring generally to Figure 6, another embodiment of inflow control device assembly 44 is illustrated. In this example, at least one check valve 48 may be positioned at each corresponding inlet 56 of the autonomous inflow control device 46. The embodiment illustrated has two inlets 56 and two check valves 48. The check valve

ball 76 or other one-way flow control member may be positioned between check valve inlet 70 and check valve outlet 72. In this example, the retaining member 82 associated with each check valve 48 is located between the check valve ball 76 and the inlet 56 to the autonomous inflow control device 46.

[0045] Each check valve 48 allows fluid to flow freely from the check valve inlet 70 to the inlet 56 of the autonomous inflow control device 46. However, when fluid flows in the opposite direction, the check valve ball 76 is moved against the corresponding ball seat 78 and fluid flow back through the inlet 56 of the inflow control device 46 is blocked. As with the embodiments described in Figures 3-5, this embodiment also may be constructed with inlets 56 and chamber 50 in desired configurations to provide autonomous flow control based on differing properties of differing fluids.

[0046] The autonomous inflow control device 46 placed in series with the check valve(s) 48 also may be arranged to control flow of injection fluids. For example, the inlet 56 to the autonomous inflow control device 46 may be oriented to receive flow from the base pipe 36 and to regulate the flow of fluids into the annulus 32 of wellbore 24. Depending on the application, the check valve 48 may be combined with the autonomous inflow control device 46 and oriented in either direction to block flow into or out of the base pipe 36.

[0047] According to one embodiment, the check valve 48 may be oriented with respect to the autonomous inflow control device 46 such that flow from the wellbore 24 through the inflow control device 46 is blocked but flow from the base pipe 36 through the inflow control device 46 is possible. For example, the orientation of the check valve(s) 48 with respect to the autonomous inflow control device 46 can be the opposite of that illustrated in Figures 5 and 6 with the autonomous inflow control device 46 regulating injection and the ball 76 of each check valve 48 blocking flow from the opposite direction. In such an arrangement, the ball 76 may be arranged to form a seal with the check valve outlet 72. In this type of embodiment, the check valve 48 may be

disabled by degrading the ball 76 or another part of the check valve 48. Disabling the check valve 48 effectively enables flow to the wellbore, e.g. injection, or flow into the base pipe through the autonomous inflow control device 46.

[0048] Referring generally to Figure 7, another embodiment of inflow control device assembly 44 is illustrated as combined with base pipe 36 and sand screen 34 of a sand screen assembly 30 which may be part of well system 20. In this embodiment, inflow control device 46, e.g. an autonomous inflow control device, is installed in an opening 84 formed through wall 38 of base pipe 36. It should be noted that other embodiments of inflow control device 46 described herein may be mounted in similar openings 84 to enable controlled communication between the interior and exterior of base pipe 36.

[0049] In the embodiment illustrated in Figure 7, housing 86, e.g. an annular housing, is disposed circumferentially around at least a portion of the circumference of base pipe 36 and over opening 84. An annular barrier 88 is provided between the housing 86 and the base pipe 36, as illustrated, to form a chamber 90, e.g. an annular chamber, in communication with the inflow control device 46 disposed in opening 84. The annular barrier 88 also comprises an opening 92 to allow fluid flow between sand screen 34 and chamber 90. The check valve 48 may be installed at opening 92, e.g. coupled to annular barrier 88, so as to block flow through opening 92 in one direction. The check valve 48 is again located in series with the inflow control device 46 and is effectively communicatively coupled with inflow control device 46 via housing 86 and chamber 90. The check valve 48 may be oriented to block flow in a desired direction, e.g. to block flow of fluid from inflow control device 46 to sand screen 34.

[0050] Figure 7 illustrates check valve 48 installed in annular barrier 88 and inflow control device 46 installed in base pipe 36. However, the positions can be reversed. For example, the inflow control device 46 may be installed at or in the annular barrier 88 and may be placed in series with the check valve 48 installed at or in the base pipe 36. It should further be noted that with respect to embodiments described herein a

plurality of inflow control devices 46 and/or check valves 48 may be used in each sand screen assembly 30.

[0051] Depending on the environment and implementation, many types of completion strings and other well strings 22 may be deployed into borehole 24 with various types of sand screen assemblies 30. The number of sand screen assemblies 30 deployed along well string 22 as well as the number of sand screen assemblies 30 positioned in each well zone 28 may vary from one operation to another. Similarly, the number and arrangement of inflow control devices 46 and the check valves 48 in each sand screen assembly 30 may be selected according to the parameters of a given operation. The check valves 48 may utilize check valve balls or other types of members to selectively block flow in one direction while allowing flow in the other direction. Similarly, inflow control devices 46 may comprise various types and arrangements of housings, inlets, outlets, chambers, and other features to provide desired autonomous responses to different fluids based on selected fluid properties.

[0052] Although a few embodiments of the disclosure have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the teachings of this disclosure. Accordingly, such modifications are intended to be included within the scope of this disclosure as defined in the claims.

CLAIMS

What is claimed is:

- 1 1. A system for use in a well, comprising:
2
3 a sand screen assembly having a base pipe, a sand screen disposed about
4 the base pipe, and an inflow control device assembly positioned to control flow of
5 a fluid between an exterior and an interior of the base pipe, the inflow control
6 device assembly comprising:
7 an inflow control device; and
8 a choke valve in fluid communication with the inflow control
9 device, the choke valve blocking fluid flow through the inflow control
10 device in a given direction.

- 1 2. The system as recited in claim 1, wherein the inflow control device comprises an
2 autonomous inflow control device which controls flow of different fluids between
3 the exterior and interior of the base pipe differently depending on at least one
4 property of the fluids.

- 1 3. The system as recited in claim 2, wherein the autonomous inflow control device
2 comprises an inlet, an outlet, and a chamber between the inlet and the outlet, the
3 inlet being oriented to create a tangential jet in the chamber as the fluid flows into
4 the chamber.

- 1 4. The system as recited in claim 1, wherein the choke valve is oriented to block
2 flow of fluid from the interior to the exterior of the base pipe.

- 1 5. The system as recited in claim 1, wherein the choke valve is oriented to block
2 flow of fluid from the exterior to the interior of the base pipe.

- 1 6. The system as recited in claim 1, wherein the check valve comprises a check
2 valve inlet, a check valve outlet, and a check valve ball between the check valve
3 inlet and the check valve outlet.
1
- 1 7. The system as recited in claim 6, wherein the check valve ball is retained between
2 the check valve inlet and the check valve outlet by a retaining member.
- 1 8. The system as recited in claim 6, wherein the inflow control device assembly
2 further comprises an annular chamber disposed about the base pipe, the check
3 valve being mounted in a wall forming the annular chamber and the inflow
4 control device being mounted in a wall of the base pipe.
1
- 1 9. The system as recited in claim 1, wherein the check valve comprises a plurality of
2 check valves.
1
- 1 10. A system, comprising:
2
3 a sand screen assembly comprising a base pipe, a sand screen, a check
4 valve to block flow of a fluid between an exterior and an interior of the base pipe
5 in a first direction, and an autonomous inflow control device coupled to the check
6 valve to allow or reduce flow of the fluid between the exterior and the interior of
7 the base pipe in a second direction according to a property of the fluid.
- 1 11. The system as recited in claim 10, wherein the autonomous inflow control device
2 comprises an inlet, an outlet, and a frustoconical section between the inlet and the
3 outlet.
- 1 12. The system as recited in claim 10, wherein the check valve comprises a check
2 valve ball.

- 1 13. The system as recited in claim 10, wherein the check valve is located between the
2 autonomous inflow control device and an interior of the base pipe.
- 1 14. The system as recited in claim 10, wherein the autonomous inflow control device
2 is located between the check valve and an interior of the base pipe.
1
- 1 15. The system as recited in claim 10, wherein the autonomous inflow control device
2 is coupled to the check valve via an annular housing mounted around the base
3 pipe.
- 1 16. The system as recited in claim 10, wherein the sand screen assembly is coupled
2 into a completion string deployed in a wellbore.
- 1 17. A method, comprising:
2
3 providing a sand screen assembly with a base pipe, a sand screen disposed
4 about the base pipe, and a flow controller having a combined check valve and
5 inflow control device;
6 coupling the sand screen assembly into a completion string; and
7 deploying the completion string downhole into a wellbore.
- 1 18. The method as recited in claim 17, wherein providing comprises providing the
2 inflow control device in the form of an autonomous inflow control device.
- 1 19. The method as recited in claim 17, wherein coupling comprises coupling a
2 plurality of the sand screen assemblies into the completion string.
- 1 20. The method as recited in claim 17, further comprising orienting the check valve
2 and the inflow control device such that the check valve blocks flow fluid from an
3 interior of the base pipe to an exterior surrounding the sand screen assembly.

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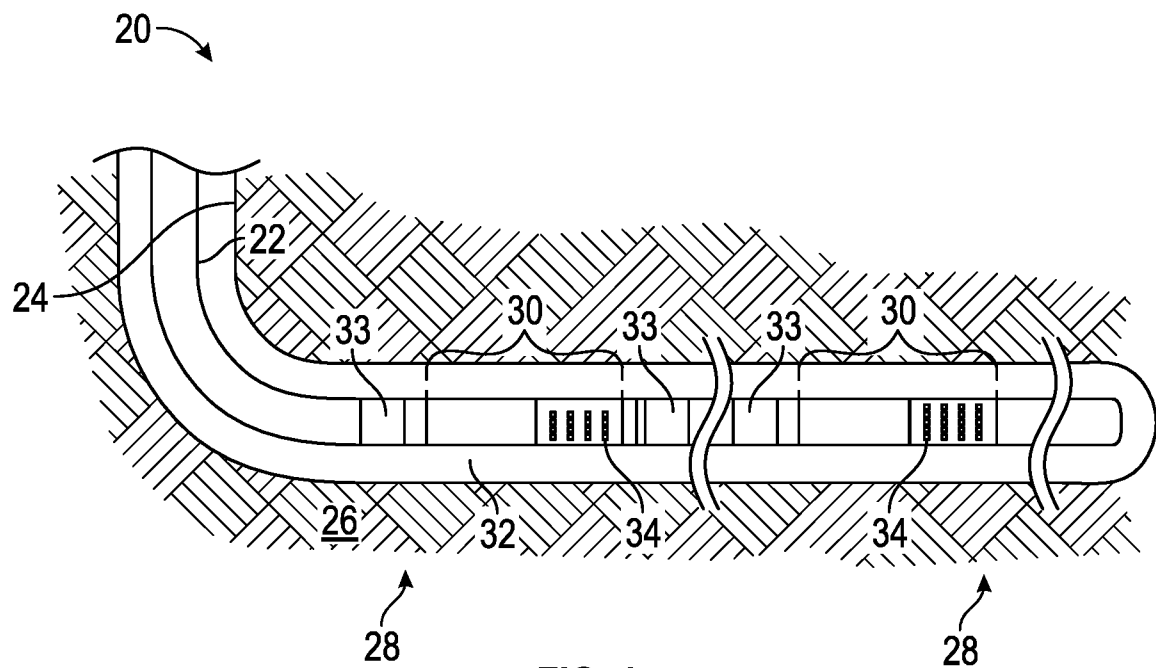


FIG. 1

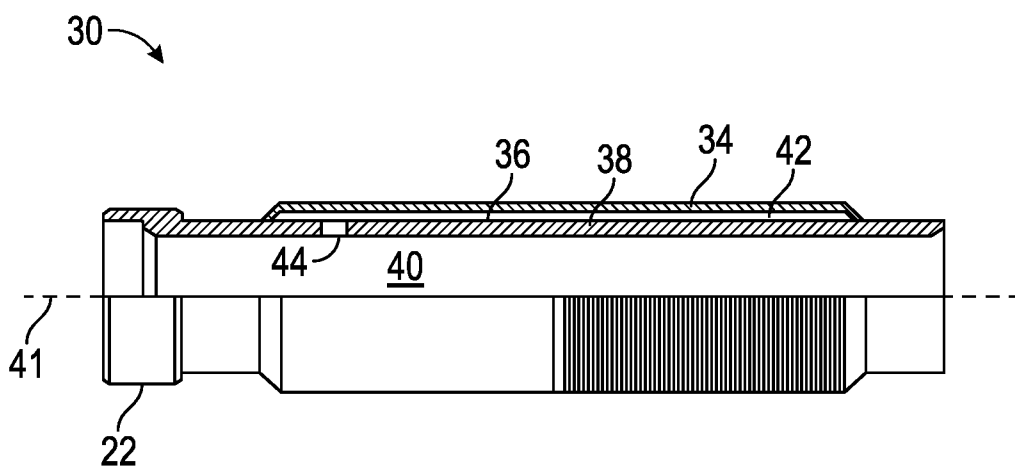


FIG. 2

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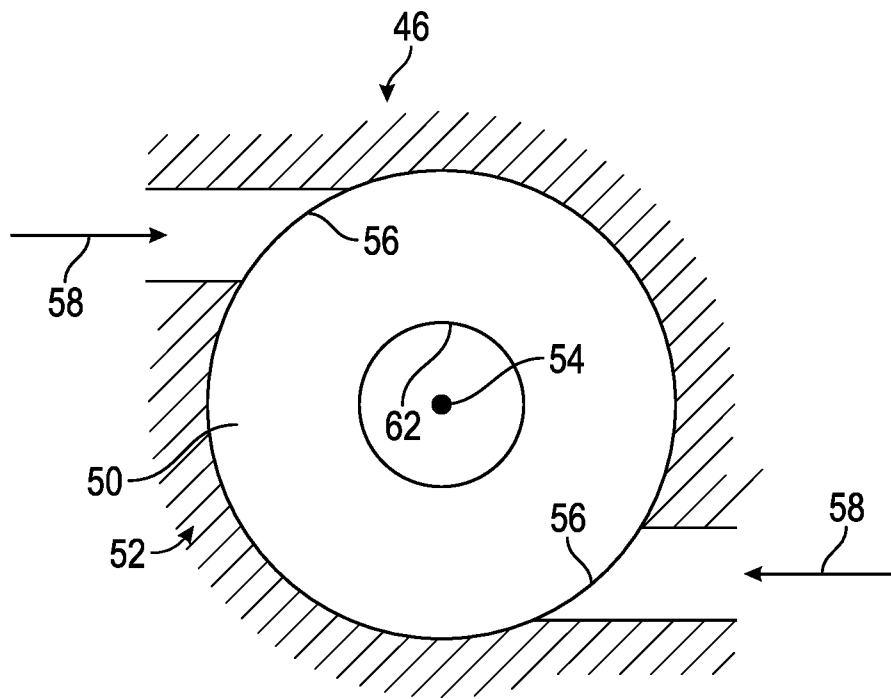


FIG. 3

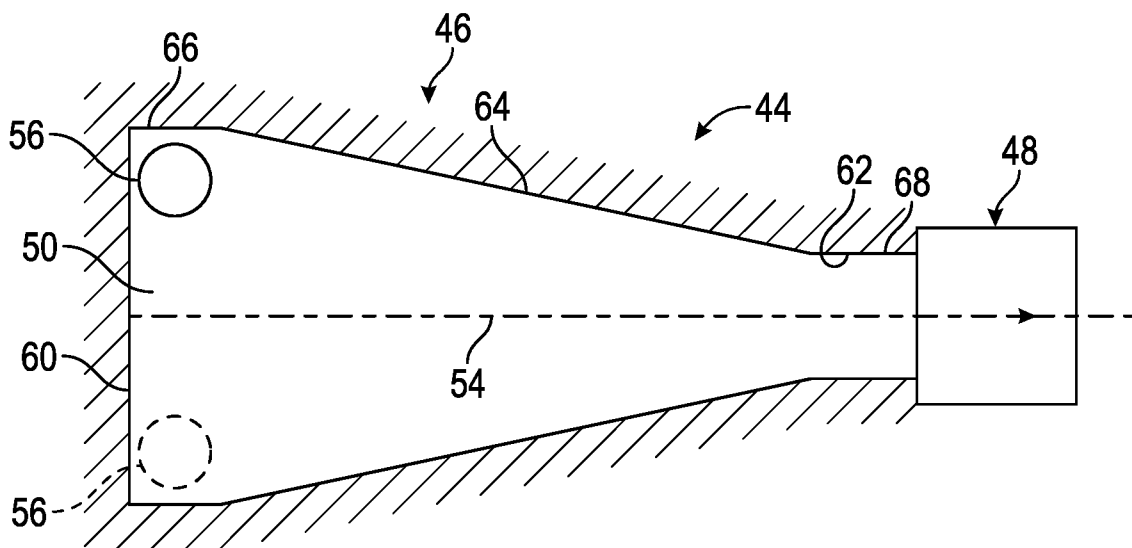


FIG. 4

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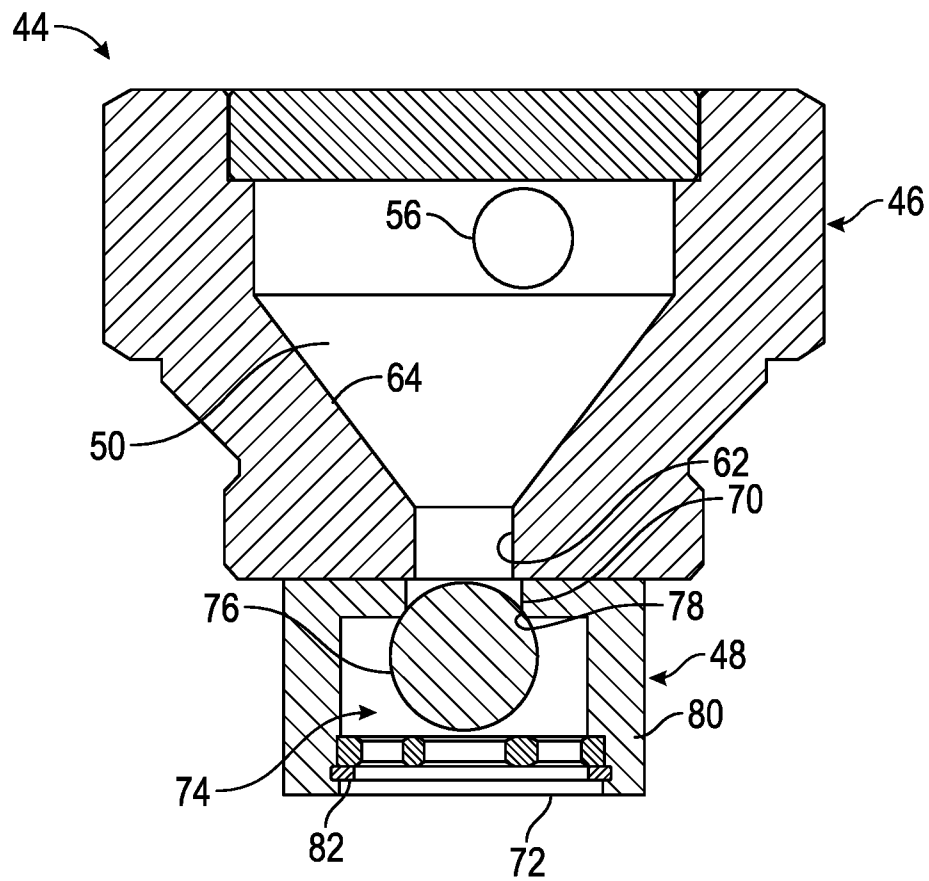


FIG. 5

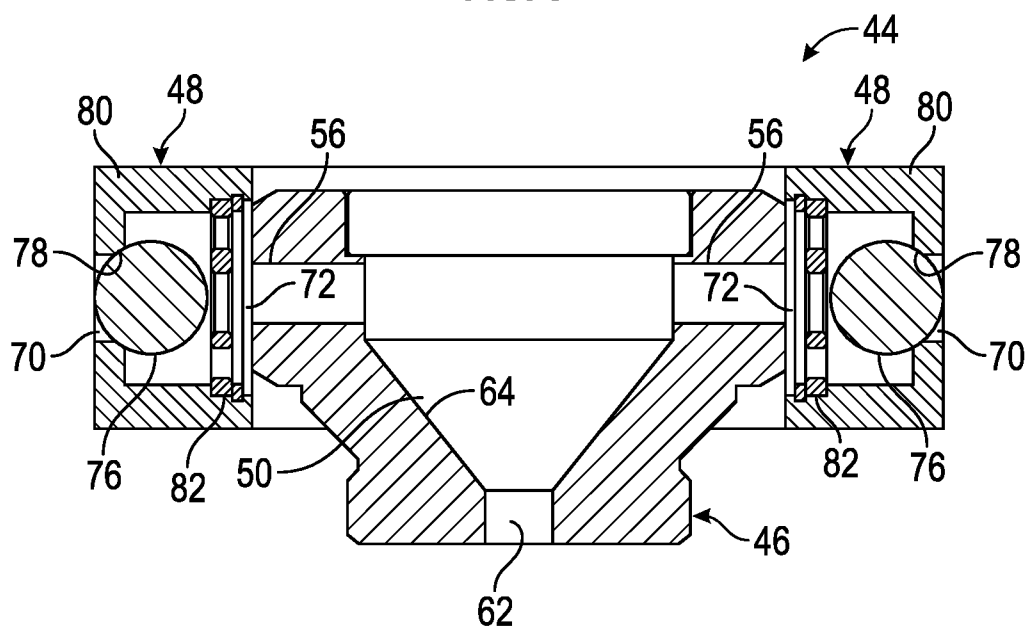


FIG. 6

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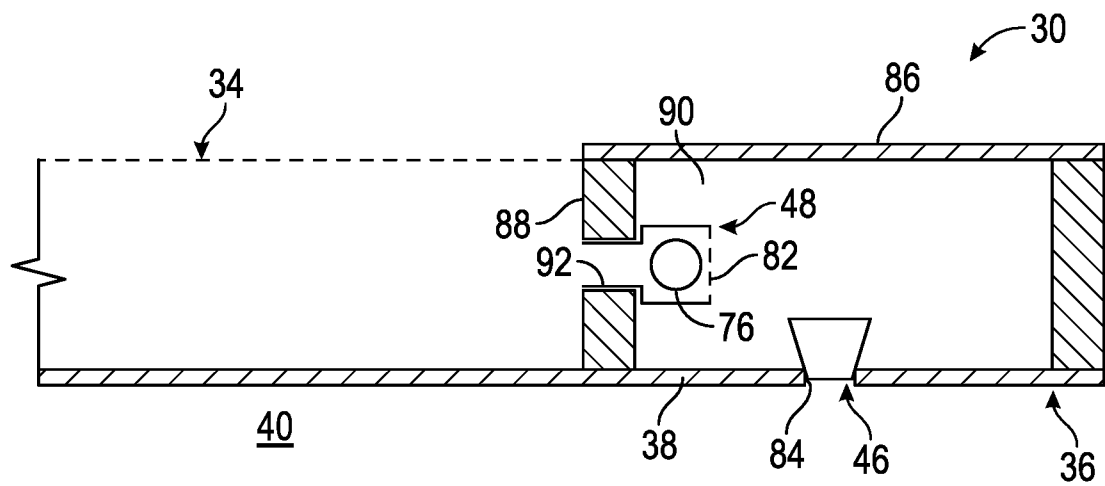


FIG. 7

A. CLASSIFICATION OF SUBJECT MATTER**E21B 43/02(2006.01)i, E21B 43/08(2006.01)i, E21B 43/12(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHEDMinimum documentation searched (classification system followed by classification symbols)
E21B 43/02; E21B 43/12; E21B 34/06; E03B 3/18; E21B 33/12; E21B 34/08; E21B 43/08Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility modelsElectronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: sand screen, autonomous, inflow, control, prevent, fluid, ball, seat, check valve**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2012-0061088 A1 (DYKSTRA et al.) 15 March 2012 See paragraphs [0005], [0021]-[0037], [0040]-[0057]; and figures 1-2, 3A-3B, 5A.	1-20
Y	US 2006-0027377 A1 (SCHOONDERBEEK et al.) 09 February 2006 See paragraphs [0014]-[0022]; and figures 4-6.	1-20
A	US 2014-0231095 A1 (LOPEZ et al.) 21 August 2014 See paragraphs [0015]-[0022], [0034]-[0035]; and figures 1, 3-4.	1-20
A	US 2002-0108755 A1 (ZISK JR., EDWARD J.) 15 August 2002 See paragraphs [0037]-[0044], [0050]; and figures 1-7, 10A-10B.	1-20
A	WO 2009-079612 A1 (HALLIBURTON ENERGY SERVICES, INC. et al.) 25 June 2009 See page 4, line 18 - page 8, line 30; page 13, line 26 - page 15, line 12; and figures 1-2, 6.	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

26 December 2016 (26.12.2016)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2016/052737

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