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FLUIDIC OSCILLATOR BYPASS SYSTEM

TECHNICAL FIELD

10 This disclosure relates generally to equipment utilized and operations performed in conjunction with a subterranean well and, in one example described below, more particularly provides a bypass system and method for use with a fluidic oscillator downhole.

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BACKGROUND

 A fluidic oscillator can produce oscillations in fluid flow using fluidic elements, such as a fluidic switch, vortex chamber, etc. Such fluid flow oscillations can be
20 used for treating or cleaning a sand control screen or gravel pack, for removing scale from casing, for treating subterranean earth formations, for example, to place matrix treatments, to acidize, etc. Therefore, it will be appreciated that improvements are continually needed in the
25 art of controlling operation of fluidic oscillators in wells.

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BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a representative partially cross-sectional view of a well system and associated method which can embody principles of this disclosure.

5 FIG. 2 is a representative cross-sectional view of a fluidic oscillator assembly that can be used in the system and method of FIG. 1, and which can embody principles of this disclosure.

10 FIG. 3 is a representative perspective view of a structure of the assembly, the structure having fluidic oscillators formed therein.

FIG. 4 is a representative cross-sectional view of the fluidic oscillator assembly of FIG. 2, with a closure thereof displaced to a oscillator output position.

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DETAILED DESCRIPTION

Representatively illustrated in FIG. 1 is a system 10 for use with a well, and an associated method, which can embody principles of this disclosure. However, it should be
20 clearly understood that the system 10 and method are merely one example of an application of the principles of this disclosure in practice, and a wide variety of other examples are possible. Therefore, the scope of this disclosure is not limited at all to the details of the system 10 and method
25 described herein and/or depicted in the drawings.

In the FIG. 1 system, a drill string 12 is positioned in a wellbore 14. A portion of the wellbore 14 is lined with casing 16 and cement 18, and another portion of the wellbore is uncased or open hole. It should be clearly understood,
30 however, that it is not necessary for any portion of the wellbore 14 to be uncased, and the method described herein

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can be practiced in any cased or uncased portion of the wellbore.

The wellbore 14 is depicted in FIG. 1 as being generally vertical. However, in other examples the wellbore 14 (or any particular portion thereof) could be horizontal, inclined or otherwise oriented. Thus, the scope of this disclosure is not limited to performance of the method in a wellbore having any particular orientation.

The FIG. 1 drill string 12 has connected therein a fluidic oscillator assembly 20, a drilling motor 22 and a drill bit 24. The fluidic oscillator assembly 20 is used to selectively transmit fluid flow oscillations 26 into an earth formation 28 penetrated by the wellbore 14. The oscillations 26 may have any desired amplitude and frequency, in keeping with the principles of this disclosure.

The oscillations 26 enhance delivery of any type of treatment into the formation 28. For example, resins or other types of sand control treatments can be flowed into the formation 28, permeability modifiers, aromatics or acids for stimulation can be flowed into the formation, etc. Thus, the scope of this disclosure is not limited to flow of any particular type of treatment fluid into the formation 28.

The drilling motor 22 is used to rotate the drill bit 24. For example, the drilling motor 22 could be a Moineau-type positive displacement motor, or a turbine drilling motor. Fluid flow through the drilling motor 22 causes rotation of the drill bit 24, although the drill bit could also be rotated by rotating the drill string 12 at the earth's surface (for example, using a rotary table or a top drive).

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In the FIG. 1 example, the drill bit 24 is used to drill through a plug 30 previously set in the casing 16. In other examples, the plug 30 could be set in an open hole portion of the wellbore 14. The plug 30 could be set for well control or other purposes.

Preferably, the plug 30 is made of a relatively easily drillable material but, if harder materials are used in the plug, a mill could be used in place of the drill bit 24. As used herein, the term "drill bit" is used to indicate a cutting tool (including, but not limited to, drills, mills, reamers, etc.).

While the drill bit 24 is being used to drill through the plug 30 (or other obstruction, or into the formation 28), fluid 32 flowed longitudinally through the drill string 12 should flow through the drilling motor 22, in order to rotate the drill bit. If the fluid 32 were to flow outward from ports 34 in the assembly 20, and into an annulus 36 external to the assembly, this would reduce the amount of fluid flowing through the drilling motor 22, and thereby reduce an efficiency and speed of the drilling.

Therefore, in the FIG. 1 example, while the drill bit 24 is being used to drill through the plug 30 (or other structure), it is desired for the fluid 32 to flow into the annulus 36 exclusively via the drilling motor 22 and drill bit. After the plug 30 (or other structure) has been drilled, and the assembly 20 is to be used to produce the oscillations 26 while the fluid 32 is flowed into the formation 28, it is desired for the fluid to flow exclusively out of the ports 34 for enhanced treatment effectiveness.

Note that it is not necessary for the fluid 32 to be the same during the drilling and formation treatment

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operations. For example, the fluid 32 could be a drilling fluid (also know as drilling "mud" to those skilled in the art) while the drill bit 24 is being rotated with the drilling motor 22, and the fluid could be a treatment fluid while the assembly 20 produces the oscillations 26 in the flow of the fluid into the formation 28.

FIG. 2 is an enlarged scale representative cross-sectional view of one example of the fluidic oscillator assembly 20 that can be used in the system 10 and method of FIG. 1. Of course, the assembly 20 can be used in other systems and methods in keeping with the principles of this disclosure.

In the FIG. 2 example, the assembly 20 includes a generally tubular housing 38 having the ports 34 formed therein for communication with the annulus 36 (see FIG. 1). Upper and lower connectors 40, 42 provide for connecting the assembly 20 in the drill string 12.

Note that it is not necessary for the assembly 20 to be connected in a drill string. The assembly 20 could, for example, be connected in a completion string, in a stimulation string, or in any other type of tubular string. Thus, the scope of this disclosure is not limited to use of the assembly 20 in a drill string.

Reciprocally and sealingly received in the assembly 20 is a closure 44 in the form of a sleeve. The closure 44 is releasably secured against displacement by a shear screw 46. Other types of releasable locks or latches (such as, snap rings, collets, shear rings, shear pins, dogs, etc.) may be used in place of, or in addition to, the shear screw 46, if desired.

A passage 48 extends longitudinally through the closure 44 and longitudinally through the assembly 20. In the FIG. 2

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position of the closure 44, fluid flow completely longitudinally through the assembly 20 is permitted. Thus, the drilling motor 22 can be used to rotate the drill bit 24 with the assembly 20 in the FIG. 2 configuration.

5 Seals 50 carried on the closure 44 are sealingly engaged in a seal bore 52 formed in the upper connector 40, and in a seal bore 54 formed in a generally tubular structure 58 received in the housing 38. The closure 44 in the FIG. 2 position, along with the seals 50, prevent fluid
10 32 in the passage 48 from flowing into an annular flow path 56 formed between the closure and the upper connector 40.

 The annular flow path 56 is in communication with an upper end of the structure 58. Fluidic oscillators 62 are formed in an outer surface 60 of the structure 58, and the
15 fluidic oscillators are in communication with the ports 34. Thus, if the annular flow path 56 is placed in communication with the passage 48, then the fluid 32 will be permitted to flow through the fluidic oscillators 62 to the openings 34 and thence outward into the annulus 36 (see FIG. 1).

20 FIG. 3 is an enlarged scale representative perspective view of an example of the structure 58 of the assembly 20, the structure having the fluidic oscillators 62 formed therein. Two fluidic oscillators 62 are formed in the structure 58, but in other examples any number of
25 oscillators may be used.

 The fluidic oscillators 62 of FIG. 3 are similar in form and operation to those described in U.S. Publication No. 2012/0168013. When permitted by displacement of the closure 44 (as described more fully below), the fluid 32 can
30 flow from the annular flow path 56 (see FIG. 2) into inlets 64 of the oscillators 62, and through the oscillators to

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outlets 66. The outlets 66 are in communication with the ports 34 in the housing 38 (see FIG. 2).

Although the oscillators 62 depicted in FIG. 3 are similar to those described in U.S. Publication No.

5 2012/0168013, other types, configurations and numbers of oscillators may be used. In addition, the outer surface 60 of the structure 58 is frusto-conical shaped for complimentary engagement with an inner surface 68 of the housing 38 (see FIG. 2), but in other examples the structure
10 could be straight cylindrical or otherwise shaped.

In the present disclosure, an example is described in which the oscillations produced by the oscillators 62 are used after the plug 30 is drilled through, in order to deliver a treatment fluid to the formation 28 (e.g., for
15 well control purposes). However, in other examples, the oscillations may not be used after a drilling operation, and may not be used for delivering a treatment fluid into a formation, but could instead be used for cleaning or treating a well screen or gravel pack, for removing scale
20 from a casing, or for other purposes.

FIG. 4 is a representative cross-sectional view of the fluidic oscillator assembly 20 of FIG. 2, with the closure 44 thereof displaced to an oscillator output (non-bypassed) position. In this position, the fluid 32 can flow into the
25 annular flow path 56 and then through the fluidic oscillators 62 in the structure 58. From the oscillators 62, the fluid 32 flows outward via the ports 34, with oscillations having been produced in the flow of the fluid by the oscillators 62.

30 To cause the closure 44 to displace to its FIG. 4 position, a plug 70 (such as, a ball, dart etc.) is disposed in the passage 48 and sealingly engaged with a seat 72 in

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the closure. For example, the plug 70 could be dropped into the drill string 12 at the surface, released from a downhole receptacle, or otherwise introduced into the passage 48.

A predetermined pressure differential is then created
5 across the plug 70. When the predetermined pressure differential is reached, the shear screw 46 shears, allowing the closure 44 to displace to its FIG. 4 position. Note that it is not necessary for the plug 70 to completely sealingly engage the seat 72, since a pressure differential can be
10 created across the plug even if it is not completely sealed in the passage 48.

With the plug 70 engaged with the seat 72 in the passage 48, flow of the fluid 32 to the drilling motor 22 (see FIG. 1) is prevented. Thus, all of the fluid 32 flowed
15 through the drill string 12 is directed to flow through the oscillators 62 and then outward via the ports 34 to the annulus 36. This achieves maximum effectiveness of the formation treatment operation, although in some examples a minimal amount of the fluid 32 could flow through the
20 drilling motor 22 (e.g., if the plug 70 does not completely seal off the passage 48 at the seat 72).

The upper connector 40 and an upper end of the closure 44 can be dimensioned so that the plug 70 will not displace into the annular flow path 56. For example, if the assembly
25 20 is substantially horizontal or inclined, and the pressure differential is not constantly maintained across the plug 70, it is possible that the plug could displace out of the passage 48. In the FIG. 4 example, if flow of the fluid 32 is then resumed, the plug 70 will displace with the flow,
30 and will again sealingly engage the seat 72, without falling into the annular flow path 56.

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It may now be fully appreciated that the above disclosure provides significant advancements to the art of controlling operation of fluidic oscillators downhole. In one example described above, flow through the fluidic oscillators 62 can be delayed until use of the drilling motor 22 is no longer needed, at which point flow to the drilling motor can be diverted to the fluidic oscillators. In this manner, both of the drilling operation and the formation treatment operation can be accomplished with only one trip of the drill string 12 into the wellbore 14.

A fluidic oscillator assembly 20 for use in a subterranean well is provided to the art by the above disclosure. In one example, the assembly 20 can comprise at least one fluidic oscillator 62 formed in a structure 58, and a closure 44 that in a first position prevents fluid flow through the fluidic oscillator 62 to an exterior of the assembly 20, and in a second position permits fluid flow through the fluidic oscillator 62 to the exterior of the assembly 20.

The structure 58 can have a longitudinal bore 54 extending through the structure 58. Fluid flow through the bore 54 may be permitted in the first position of the closure 44, and fluid flow through the bore 54 may be prevented in the second position of the closure 44. The closure 44 may be sealingly and slidingly received in the bore 54.

The closure 44 can have a longitudinal passage 48 extending through the closure, and a plug 70 can be received in the passage. The closure 44 may be releasably secured against displacement relative to the structure 58, and a predetermined pressure differential across the plug 70 may release the closure 44 for displacement relative to the

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structure 58. The predetermined pressure differential across the plug 70 can displace the closure 44 from the first position to the second position.

5 In the second position of the closure 44, fluid flow may pass through the fluidic oscillator 62 between the structure 58 and an outer generally tubular housing 38 in which the structure is received.

10 A method is also provided to the art by the above disclosure. In one example, the method can comprise: flowing fluid 32 longitudinally through a fluidic oscillator assembly 20; then diverting the fluid 32 to flow outward from the fluidic oscillator assembly 20 via at least one fluidic oscillator 62 of the fluidic oscillator assembly 20, the fluid 32 being prevented from flowing longitudinally
15 through the fluidic oscillator assembly 20.

The diverting step can comprise installing a plug 70 in a longitudinal passage 48 of the fluidic oscillator assembly 20. The diverting step can further comprise applying a predetermined pressure differential across the plug 70,
20 thereby displacing a closure 44 from a first position in which the closure prevents flow of the fluid 32 through the fluidic oscillator 62 to a second position in which flow of the fluid 32 through the fluidic oscillator 62 is permitted.

25 The passage 48 may be formed through the closure 44, and the closure 44 may be sealingly and slidingly received in a structure 58, with the fluidic oscillator 62 being formed in the structure 58.

30 The flowing step can comprise flowing the fluid 32 through a drilling motor 22 connected between the fluidic oscillator assembly 20 and a drill bit 24. The diverting step can comprise preventing flow of the fluid 32 through the drilling motor 22.

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The diverting step may include the fluidic oscillator 62 producing oscillations 26 in the fluid flow, the fluid flow oscillations being communicated into the earth formation 28.

5 A well system 10 is also described above. In one example, the well system 10 can comprise a drill string 12 including a fluidic oscillator assembly 20, a drilling motor 22, and a drill bit 24, the drilling motor 22 being disposed between the drill bit 24 and the fluidic oscillator assembly
10 20. The fluidic oscillator assembly 20 may include a closure 44 that in a first position prevents fluid flow through a fluidic oscillator 62 to an annulus 36 formed between the drill string 12 and a wellbore 14, and in a second position permits fluid flow through the fluidic oscillator 62 to the
15 annulus 36.

 The fluid flow through the fluidic oscillator assembly 20 to the drilling motor 22 may be permitted in the first position of the closure 44, and the fluid flow through the fluidic oscillator assembly 20 to the drilling motor 22 may
20 be prevented in the second position of the closure 44.

 The fluidic oscillator 62 can be formed in a structure 58, the structure having a longitudinal bore 54 extending through the structure 58, and the closure 44 may be sealingly and slidingly received in the bore 54.

25 The closure 44 may be releasably secured against displacement relative to the fluidic oscillator 62, and a predetermined pressure differential across the plug 70 can release the closure for displacement relative to the fluidic oscillator 62.

30 Although various examples have been described above, with each example having certain features, it should be understood that it is not necessary for a particular feature

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of one example to be used exclusively with that example. Instead, any of the features described above and/or depicted in the drawings can be combined with any of the examples, in addition to or in substitution for any of the other features
5 of those examples. One example's features are not mutually exclusive to another example's features. Instead, the scope of this disclosure encompasses any combination of any of the features.

Although each example described above includes a
10 certain combination of features, it should be understood that it is not necessary for all features of an example to be used. Instead, any of the features described above can be used, without any other particular feature or features also being used.

15 It should be understood that the various embodiments described herein may be utilized in various orientations, such as inclined, inverted, horizontal, vertical, etc., and in various configurations, without departing from the principles of this disclosure. The embodiments are described
20 merely as examples of useful applications of the principles of the disclosure, which is not limited to any specific details of these embodiments.

In the above description of the representative examples, directional terms (such as "above," "below,"
25 "upper," "lower," etc.) are used for convenience in referring to the accompanying drawings. However, it should be clearly understood that the scope of this disclosure is not limited to any particular directions described herein.

The terms "including," "includes," "comprising,"
30 "comprises," and similar terms are used in a non-limiting sense in this specification. For example, if a system, method, apparatus, device, etc., is described as "including"

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a certain feature or element, the system, method, apparatus, device, etc., can include that feature or element, and can also include other features or elements. Similarly, the term "comprises" is considered to mean "comprises, but is not
5 limited to."

Of course, a person skilled in the art would, upon a careful consideration of the above description of representative embodiments of the disclosure, readily appreciate that many modifications, additions,
10 substitutions, deletions, and other changes may be made to the specific embodiments, and such changes are contemplated by the principles of this disclosure. For example, structures disclosed as being separately formed can, in other examples, be integrally formed and *vice versa*.
15 Accordingly, the foregoing detailed description is to be clearly understood as being given by way of illustration and example only, the spirit and scope of the invention being limited solely by the appended claims and their equivalents.

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WHAT IS CLAIMED IS:

1. A fluidic oscillator assembly for use in a subterranean well, the assembly comprising:

5 at least one fluidic oscillator formed in a structure;
and

a closure that in a first position prevents fluid flow through the fluidic oscillator to an exterior of the assembly, and in a second position permits fluid flow
10 through the fluidic oscillator to the exterior of the assembly.

2. The fluidic oscillator assembly of claim 1, wherein the structure has a longitudinal bore extending
15 through the structure, wherein fluid flow through the bore is permitted in the first position of the closure, and wherein fluid flow through the bore is prevented in the second position of the closure.

20 3. The fluidic oscillator assembly of claim 1, wherein the structure has a longitudinal bore extending through the structure, and wherein the closure is sealingly and slidingly received in the bore.

25 4. The fluidic oscillator assembly of claim 1, wherein the closure has a longitudinal passage extending through the closure, and further comprising a plug received in the passage.

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5. The fluidic oscillator assembly of claim 4,
wherein the closure is releasably secured against
displacement relative to the structure, and wherein a
predetermined pressure differential across the plug releases
5 the closure for displacement relative to the structure.

6. The fluidic oscillator assembly of claim 5,
wherein the predetermined pressure differential across the
plug displaces the closure from the first position to the
10 second position.

7. The fluidic oscillator assembly of claim 1,
wherein, in the second position of the closure, fluid flow
passes through the fluidic oscillator between the structure
15 and an outer generally tubular housing in which the
structure is received.

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8. A method, comprising:

flowing fluid longitudinally through a fluidic oscillator assembly in a well;

then diverting the fluid to flow outward from the
5 fluidic oscillator assembly via at least one fluidic oscillator of the fluidic oscillator assembly, the fluid being prevented from flowing longitudinally through the fluidic oscillator assembly.

10 9. The method of claim 8, wherein the diverting comprises installing a plug in a longitudinal passage of the fluidic oscillator assembly.

10. The method of claim 9, wherein the diverting
15 further comprises applying a predetermined pressure differential across the plug, thereby displacing a closure from a first position in which the closure prevents flow of the fluid through the fluidic oscillator to a second position in which flow of the fluid through the fluidic
20 oscillator is permitted.

11. The method of claim 10, wherein the passage is formed through the closure, and wherein the closure is sealingly and slidingly received in a structure, the fluidic
25 oscillator being formed in the structure.

12. The method of claim 8, wherein the flowing further comprises flowing the fluid through a drilling motor connected between the fluidic oscillator assembly and a
30 drill bit.

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13. The method of claim 12, wherein the diverting further comprises preventing flow of the fluid through the drilling motor.

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14. The method of claim 8, wherein the diverting further comprises the fluidic oscillator producing oscillations in the fluid flow, the fluid flow oscillations being communicated into the earth formation.

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15. A well system, comprising:

a drill string including a fluidic oscillator assembly,
a drilling motor, and a drill bit, the drilling motor being
disposed between the drill bit and the fluidic oscillator
5 assembly, and

wherein the fluidic oscillator assembly includes a
closure that in a first position prevents fluid flow through
a fluidic oscillator to an annulus formed between the drill
string and a wellbore, and in a second position permits
10 fluid flow through the fluidic oscillator to the annulus.

16. The well system of claim 15, wherein fluid flow
through the fluidic oscillator assembly to the drilling
motor is permitted in the first position of the closure, and
15 wherein fluid flow through the fluidic oscillator assembly
to the drilling motor is prevented in the second position of
the closure.

17. The well system of claim 15, wherein the fluidic
20 oscillator is formed in a structure, wherein the structure
has a longitudinal bore extending through the structure, and
wherein the closure is sealingly and slidingly received in
the bore.

25 18. The well system of claim 15, wherein the closure
has a longitudinal passage extending through the closure,
and further comprising a plug received in the passage.

19. The well system of claim 18, wherein the closure
30 is releasably secured against displacement relative to the

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fluidic oscillator, and wherein a predetermined pressure differential across the plug releases the closure for displacement relative to the fluidic oscillator.

- 5 20. The fluidic oscillator assembly of claim 19, wherein the predetermined pressure differential across the plug displaces the closure from the first position to the second position.