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ON-DEMAND VIBRATION TOOL FOR DRILLING APPLICATIONS

Abstract

There is a downhole tool for use in a drill string including a friction-reducing vibration tool and a bypass control. The vibration tool includes a rotary driving device responsive to fluid flow in the drill string, a valve including a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device, and a bypass passage around or through one or more of the rotary driving device and the valve. The bypass control has a sensor for detecting a stimulus, a bypass actuator for controlling an amount of fluid flow through the bypass passage to activate or deactivate the vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor. There is a method of activating or deactivating the friction-reducing vibration tool in a drill string by detecting a stimulus using the sensor and electrically activating or deactivating the tool in response to signals from the sensor.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS [0001] This application is a continuation-in-part of application Ser. No. 18/178,388, filed Mar. 3, 2023, which claims priority to Canadian Application No. 3,180,354, filed Oct. 28, 2022; and this application also claims priority to Canadian Application No. 3,271,982, filed Apr. 27, 2025, the disclosures of which are incorporated herein by reference.

TECHNICAL FIELD
[0002] This relates to electrically activating and deactivating vibration tools used in the drilling of oil and gas wells.
BACKGROUND
[0003] Many downhole tools operate based on fluid pressure. By diverting or altering a flow path through a tool, various systems and functions can be activated or deactivated. Sometimes this can be accomplished through fully mechanical means, such as dropping a ball from surface into a ball seat or having a spring that allows a sleeve to travel and block/unblock a flow path based on the pressure or amount of flow.
[0004] The downside of such activation devices is that they either only allow for a single “on” activation, or they limit the available flow parameters in either the “on” or “off” position. It is advantageous to have an activation system that can both activate and deactivate a system that is not directly tied to fluid flowrate, or a mechanical spring.
[0005] When drilling oil and gas wells, a directional approach to drilling is often employed, where the first section of the well is vertical, and the subsequent section is lateral (or horizontal). Drilling the horizontal section has various challenges. A significant challenge is to effectively transfer the weight of the drill string in the vertical section to the drill bit in the horizontal section. Friction created as the drill string advances through the horizontal section can cause difficulties. One method to aid in the weight transfer is through the use of an axial vibration tool, where one or multiple tools are placed in various locations throughout the string, and help to break the wellbore friction by imparting vibration to the drill string.
[0006] It is often beneficial to not have the vibration tool activate until it has reached the lateral section of the wellbore. This can be beneficial for several reasons, including preventing damage to casing, and extending the life of the components by only operating as needed.
[0007] Several current methods exist for activating such an assembly, many of which are based on dropping a projectile from the surface in order to modify the flow path through the tool and activate the valve. Often these methods are a simple “on” switch, with no ability to turn the tool off, and the drilling string must be tripped out of hole in order to remove the projectile and reset the tool. This can be a major inconvenience when drilling a well with multiple “legs” or lateral sections.
SUMMARY
[0008] There is disclosed in one embodiment a downhole tool for use in a drill string. The

downhole tool includes a friction-reducing vibration tool which includes a rotary driving device responsive to fluid flow in the drill string, a valve including a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device, and a bypass passage around or through one or more of the rotary driving device and the valve. The downhole tool includes a bypass control, comprising a sensor for detecting a stimulus, a bypass actuator for controlling an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor indicative of the stimulus being detected.

[0009] In various embodiments, there may be included any one or more of the following features: the stimulus is a condition downhole; the stimulus is a control signal received from surface; the control signal is a series of timed pump cycles; the control signal is a series of timed rotary cycles; the control signal is a variation in pressure cycles; the rotary driving device is a Moineau-style rotor within a stator; the bypass actuator is an electric motor and a ball screw; the bypass actuator is a valve poppet that is axially moveable to vary the amount of fluid flow through the bypass passage; and the sensor is one or more of: an accelerometer, a magnetometer, a pressure sensor or a thermocouple.

[0010] There is disclosed in one embodiment a method of activating or deactivating a friction-reducing vibration tool in a drill string. A stimulus is detected using a sensor. The friction-reducing vibration tool is electrically activated or deactivated in response to signals from the sensor indicative of the stimulus being detected.

[0011] In various embodiments, there may be included any one or more of the following features: generating a control signal from surface, and transmitting the control signal downhole, wherein the control signal is the stimulus; activating or deactivating a plurality of friction-reducing vibration tools in a drill string at the same time using the control signal; wherein the friction-reducing vibration tool comprises: a rotary driving device responsive to fluid flow in the drill string, a valve including a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device, and a bypass passage around or through one or more of the rotary driving device and the valve, and wherein electrically activating or deactivating the friction-reducing vibration tool comprises activating or deactivating a bypass control to vary the flow through the bypass passage; the stimulus is a condition downhole; the control signal is a series of timed pump cycles; the control signal is a series of timed rotary cycles; the control signal is a variation in pressure cycles; and the bypass control includes the sensor, a bypass actuator for controlling an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor indicative of the stimulus being detected.

[0012] These and other aspects of the device and method are set out in the claims.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Embodiments Will Now be Described with Reference to the Figures, in which Like Reference Characters Denote Like Elements, by Way of Example, and in which:

[0014] FIG. **1** is a cross-section of an activation device having a valve according to one embodiment.

[0015] FIG. **2** is a cross-section of the valve of FIG. **1** having a valve poppet in an open position.

[0016] FIG. **3** is a cross-section of the valve poppet of FIG. **2** in a closed position.

[0017] FIG. **4** is a cross-section of the activation system of the activation device of FIG. **1**.

[0018] FIG. **5** is a schematic of a lateral well profile.
[0019] FIG. **6** is a cross-section of an activation device according to another embodiment.
[0020] FIG. **7** is a cross-section of an electronics section of the activation device of FIG. **6**.
[0021] FIG. **8** is a cross-section of the activation device of FIG. **6** in a non-activated position.
[0022] FIG. **9** is a cross-section of the activation device of FIG. **6** in an activated position.
[0023] FIG. **10** is a cross-section of a power section assembly of the activation device of FIG. **6**.
[0024] FIG. **11** is a cross-section of the valve assembly of the activation device of FIG. **6**.
[0025] FIG. **12** is a chart showing the pressure signals when the valve is activated and not activated.
[0026] FIG. **13** is a partial cross-section of an electronics section of an embodiment of the activation device having a turbine.
[0027] FIG. **14** is a close-up drawing view of FIG. **13**.
[0028] FIG. **15** is a schematic of a lateral well profile with multiple friction-reducing vibration tools in the drill string.
[0029] FIG. **16** is a schematic of a downhole tool including friction-reducing vibration tool and a bypass control.
[0030] FIGS. **17**A to **17**D show section views of a cross-section of a downhole tool including a friction-reducing vibration tool with a bypass control below the vibration tool. The downhole tool in FIGS. **17**A to **17**D are shown with the most uphole portion of the tool in FIG. **17**A and the most downhole portion of the tool in FIG. **17**D, with the figures placed in order from most uphole to most downhole from **17**A to **17**D.
[0031] FIGS. **18**A to **18**C show section views of a cross-section of a close-up of the downhole tool of FIGS. **17**A to **17**D. The downhole tool in FIGS. **18**A to **18**C are shown with the most uphole portion of the tool in FIG. **18**A and the most downhole portion of the tool in FIG. **18**C, with the FIG. **18**B being the portion of the tool between FIGS. **18**A and **18**C.

DETAILED DESCRIPTION

[0032] Immaterial modifications may be made to the embodiments described here without departing from what is covered by the claims.
[0033] There is disclosed in one embodiment a method of activating a linear valve in order to divert or alter the fluid path through a tool in response to a measured or transmitted stimuli.
[0034] There is disclosed in one embodiment a method of activating a rotary valve in a downhole tool through an electronically powered apparatus in response to a downhole measurement or pre-set activation criterion.
[0035] As shown in FIG. **1**, there is an activation device **50** within an assembly with a series of housings **140**, **144**, and **142** that separates an internal fluid path **150**, often referred to as the standpipe from the external fluid path, or annulus, of the drilling string. The internal fluid path **150** is uninterrupted through the housing and progresses through the centralizer **100** that holds the electronics package in the center of the housing **140**. A pressure sleeve **102** holds a battery **108**, sensor package **104**, snubber **110** and is connected to the motor bulkhead **106**. The area within the centralizer and around the pressure sleeve **146** and **152** forms part of the continuous fluid path.
[0036] The sensor package could also have a receiver, for receiving wireless transmissions for activation/deactivation, alternatively or additionally it could contain one or more of an accelerometer, magnetometer, pressure sensor, or thermocouple. The sensor can detect a condition downhole, and a processor may operate the valve poppet in response to the condition detected. In a preferred embodiment, the sensor may include an accelerometer and a magnetometer to determine an inclination setting using the processor. In other embodiments, mechanical and/or pressure switches could be used without a processor, which would have a simpler design but would be less precise and more complicated to turn off. The battery may be connected to the sensor and the processor. Other power sources can be used. For example, a turbine **400** (FIG. **14**) could be used as a power source, which would be able to harness power from the fluid flow within the system.

Below the motor bulkhead **106** are further components that will be detailed in later figures.

[0037] The sensor package allows for the operation of an electronically activated valve based on conditions downhole. Various types of valves can be used with the sensor package. In one embodiment of a downhole valve for use in a standpipe shown in FIGS. **2** and **3**, there may be a valve body **122** defining a flow path and a valve positioner, for example, valve poppet **112**, that is moveable relative to the valve body to vary flow through the flow path. The downhole valve may be any one of various types of valves, including a rotary valve, a poppet valve or other valve that can be activated based on readings of the sensors. An electrically activated linear activation system is connected to the valve positioner to move the valve positioner relative to the valve body. The sensor detects a condition downhole and the processor is configured to move the valve positioner relative to the valve body to vary flow through the flow path in response to the condition detected. The operation of the valve may activate a vibration tool or other downhole tool by diverting flow to or from the downhole tool. For example, the valve may direct flow either through a bypass passage or through the valve of a vibration tool to turn the vibration tool on or off. Optionally, the valve may incrementally vary the amount of flow between the bypass passage and the valve of the vibration tool to vary the magnitude of vibrations created by the vibration tool. In another embodiment, the operation of the valve may activate an activated reamer. In general, embodiments of the electrically activated downhole valve described herein may be used to activate any type of downhole tool which can be fluid activated and for which it is desirable for the tool to be predictably activated or deactivated.

[0038] As shown in FIGS. **2** and **3**, the valve body **122** has one or multiple openings **136** that split the fluid path into an internal flow path **154** or an external flow path **164** and **156**. The valve poppet **112** is located within the valve body **122**, and can close off the internal fluid path that is composed of a wash tube **130** and potentially various other components below 132. An interface **172** seals the bore for the activation unit. In embodiments where the activation device is attached to a vibration tool having a rotor and a stator, the interface **172** forms part of the rotary to stationary interface and keeps the electronics stationary and the rotor rotational. Since the rotor has an eccentric rotation, two carbide plates may be used for the interface and seal.

[0039] The valve body **122** and valve poppet **112** collectively define a downhole valve that is installed in the standpipe. The valve body **122** has a flow path through the valve body. The valve poppet **112** sits within the valve body **122** and is axially movable in a direction parallel with the standpipe when in use. It will be understood that the valve poppet **112** being moveable in a direction parallel to the standpipe does not mean that the poppet moves exactly parallel to the axis of the standpipe, but that the substantial direction of movement of the poppet is along the axis of the drill string at the location of the valve in the drill string.

[0040] The electronics package includes an electrically activated linear activation system connected to the valve poppet **112** to move the valve poppet axially. The linear activation system may include an electric motor and a ball screw. Other mechanisms may be used to electrically activate the valve poppet.

[0041] FIGS. **2** and **3** show the valve poppet **112** in its two nominal positions, open or closed, respectively. The flow through the flow path varies as the valve poppet is moved axially.

[0042] In the open position in FIG. **2**, the poppet rod **114** is retracted, thereby exposing the valve body's internal fluid path **148**, and allowing flow through one or more openings **136** to the washpipe through the path **154**. The one or more openings in the valve body are at least partially covered by the valve poppet when the valve poppet is moved axially into the closed position. Various different configurations of openings and flow paths can be used. The size and location of the flow paths can control the size of the vibrations that can be generated in a vibration tool. When the valve is in the open position, flow may pass through both the internal fluid path and the external flow path **164**.

[0043] In the closed position in FIG. **3**, the poppet rod **114** is extended, thereby positioning the valve poppet **112** directly in the valve body's internal fluid path **148**, and preventing through flow. This causes the entirety of the flow to progress through the outside fluid path **164**.

[0044] The open position may be partially or fully open and allow fluid flow through the valve body's internal flow path **148**. The closed position may be partially or fully closed and allow reduced or no flow through the valve body's internal flow path **148**. As shown in FIGS. **2** and **3**, the flow path through the valve body comprises at least two flow paths, one through the valve body's internal flow path **148** and the other into the washpipe flow path **154** and the axial movement of the valve poppet varies the amount of flow through each of the at least two flow paths. In some embodiments, the flow path modified by the downhole valve includes a first flow path in fluid connection with a passage between a rotor and a stator, and a second flow path in fluid connection with a bore in the rotor. In some embodiments, all of the at least two flow paths are contained within the standpipe, meaning that the valve operates to create vibration using positive pressure within the system rather than negative pressure.

[0045] FIG. **4** shows further details of the activation system. The motor bulkhead contains a motor **120** and a ball screw **128** that is coupled through coupling **118** to the poppet rod **114**. The bulkhead additionally has a floating piston **126** that is pressure compensated to the standpipe through a port hole **168**, and sealed against the bulkhead using o-rings **160** and against the poppet rod **114** using an o-ring or u-cup style seal **170**. The bulkhead is filled with oil for the operation of the motor and ball screw. Additionally, a gear box could be located between the motor **120** and ball screw **128** by extending the motor bulkhead. A gearbox has the additional benefit of increasing the closing force that can be applied by the ball screw **128** through the poppet rod **114** onto the valve poppet **112**.

[0046] The valve body **122** contains a valve seat **124** that can be made of a hard material such as tungsten carbide to receive the valve poppet **112** once the system is activated. Other hard materials can be used. The valve poppet may also be made from a hard material such as tungsten carbide or other hard material. Additionally a seat lock **116** is positioned below the valve seat **124** to ensure it does not come loose or rotate during operation. The downhole valve may be installed to activate a vibration tool during drilling. The hard material used in the system components could be other components with a hard-faced layer other than tungsten carbide such as welded tungsten carbide with matrix or other materials created through other processes such as surface hardening steel. In a preferred embodiment, the hard material is formed using sintered carbide components to prevent wash damage on the valve components.

[0047] FIG. **5** shows an overview schematic of a lateral or deviated well plan for a drilling operation. A drilling rig **178** is installed at surface. In this embodiment, the vertical section of the well **180** is cased. In the following vertical section **182** and the curve **184**, it is relatively easy to transfer the weight of the drill collar in the vertical section to the drill bit **188**. However, as the lateral section of the well **186** extends, it can be very difficult to transfer weight to the drill bit **188**. For this reason, vibration systems are employed which convert a pressure pulse into axial movement of the drill string. Although the horizontal portion of the well is shown as being level, a well bore may be described as horizontal despite not being precisely level. A horizontal portion of a wall may include a slight incline or slight decline relative to a precise measure of horizontal. However, it will be understood that a well bore that has a significant horizontal component may be described as being horizontal.

[0048] It is disadvantageous to have a vibration system that is always on, as the vibration can be damaging to the casing **180** when the system is activated inside of it. Instead, it is ideal to be able to activate the system “on-demand”. When drilling a well with multiple lateral legs, the vibration system may be pulled back into the vertical cased section, so it is also advantageous to be able to turn the system “off” without having to trip and remove a mechanical activation device such as a ball or a dart.

[0049] The activation tools described herein provide for a method of activating a downhole valve for use in a standpipe. A condition downhole is detected using a sensor. The downhole valve is electrically activated based on the detected condition downhole. For example, the detected condition downhole is indicative that the standpipe is in a horizontal section of a well. The downhole valve may be used to activate a vibration tool during drilling. Various types of valves may be used to achieve this vibration, including any of the valve arrangements described herein.

[0050] As shown in in FIG. **6**, the activation device includes an electronics assembly **200**, a power section assembly **242** and a valve assembly **300**, each assembly being composed of both housings **206**, **210**, **244**, **302**, **304** and internal components **208**, **204**, **246**, **248**, **316**, **318**. The housings have an uphole connection **202** which is designed to be threaded into the drill string, and a lower connection **320** designed to be threaded into either the drill string or a pressure responsive device such as a shock tool.

[0051] The electronics assembly **200** consists of two housings **206**, **210** to facilitate assembly of the internal sonde **208** and bypass assembly **204** and to carry the loads transmitted through the drill string.

[0052] Below the electronics assembly **200** is the power section assembly **242** which consists of a stator **244** and a rotor **246**, as well as the rotary to stationary diverter assembly **248**. This assembly contains the interface between the electronics assembly internals **208** and **204** which are stationary relative to the housing, and the rotor **246** which moves both rotational and eccentrically within the stator **244**.

[0053] Then at the bottom of the tool is the valve assembly **300**, which contains external housings **302** and **304** for facilitating assembly and to carry the drill string loads, as well as an internal flexshaft **316** that connects the rotor **246** to the valve **318**. Alternatively, the flex shaft could be replaced with a constant velocity joint.

[0054] The electronics assembly **200** is further detailed in FIG. **7**.

[0055] The assembly is composed of two housings **206** and **210** for ease of assembly. The housings define an internal flow path **272**. Inside the housings is a sonde **208** with a threaded mount on the downhole side, and a floating mount **212** on the uphole side. The floating mount **212** diverts the flow around the sonde. The sonde has a pressure housing **214** which contains a battery **216**, a sensor and logic board or processor **218**, and a snubber **220** for absorbing axial vibration. The pressure housing **214** connects to the motor bulkhead **222**, which houses the motor and is attached to the ball screw **224** for increasing the closing power of the assembly. An electronics section **276** houses the electric motor, ball screw drive, and oil compensation piston. Outside of the electronics section is an internal flow path **274**. A bore **278** has two o-rings to seal on a tube that goes to the rotary to stationary interface. The tube is allowed to move axially to accommodate changes of length of components. The axial movement of the tube allows for either tolerance stack up or component rework to fix damages. The base of the electronics assembly is a threaded connection **280**.

[0056] Further details of the activation system are shown in FIGS. **8** and **9**.

[0057] The bypass assembly has two nominal positions, open as shown in FIG. **8**, and closed as shown in FIG. **9**. The sonde contains the motor and motor bulkhead **234**, which is connected to the ball screw **236**. These components are not shown in detail but are commonly used in MWD pulser assemblies.

[0058] Below is the poppet rod **226**, that is attached to the poppet head **228**. The poppet rod **226** is driven by the motor **234** and ball screw **236**, and changes position within the bypass sleeve **230**. The bypass sleeve is held in place by the thread lock **240** to prevent it from moving axially or rotating relative to the bypass centralizer **238**. When the bypass assembly has not been activated, flow is able to go through the outer flow path, through the outside of the bypass centralizer **238** or through the inner flow path of the bypass sleeve **230**.

[0059] When the bypass assembly is activated, the poppet head **228** moves axially into the bypass sleeve **230**, and thereby diverts 100% of the flow through the outer flow path around the bypass centralizer **230**.

[0060] The power section assembly is connected to the lower end of the bypass centralizer **232** in such a way that it can be easily inserted after the electronics have been assembled. This allows for separate assembly of the electronics package from the rest of the tool.

[0061] As shown in FIG. **10**, the power section assembly **242** is primarily composed of an outer housing **244** called a stator, which is a steel tube with rubber bonded to the internal diameter. The rubber is profiled according to the principles of a Moineau pump, and has a corresponding rotor **246**. A flow passage **266** is defined by the space between said rotor and stator. The rotor **246** also has a through bore **262** that allows fluid to flow through the assembly without entering the power section flow passage **266**.

[0062] Additionally, the assembly has an upper thread **270** which connects to the housing of the electronics section, and a connecting tube **250** which can be inserted into the bypass centralizer **238** of the electronics assembly. This configuration allows for easy assembly of the electronics assembly **200** to the power section assembly **242**.

[0063] The connecting tube **250** is inserted into the flow centralizer **252**, which has an outer flow area **264** that leads to the power section flow passage **266**. Pressed into the flow centralizer is a stationary orifice **254** that can be made of a hard material such as carbide and forms the stationary to rotary interface with the rotor **246**. The rotor has a rotating orifice **256** pressed into an orifice adaptor **258** that is then threadedly connected to the rotor **246**. The stationary orifice **254** is sized larger than the rotating orifice **256** so that even during the eccentric motion of the rotor **246** the flow path **262** is not restricted.

[0064] Additionally, a wave spring **260** which in alternate embodiments could also be a Belleville spring, preloads the stationary and rotating orifices against each other when the electronics housing **210** is threaded into the upper end of the stator **244**. At the bottom of the power section assembly, connection **286** is a stator connection and connection **284** is a rotor connection.

[0065] The valve section is shown in FIG. **11**. In this embodiment, a flexshaft **316** is used to connect the rotor **246** to the valve assembly **318**. This flexshaft contains a through bore **350** which once assembled is a continuation of the rotor through bore **262** shown in FIG. **10**. Additionally, an outer flow path **352** exists around the outside of the flexshaft **316** and is a continuation of the power section flow path **266** from FIG. **10**. The valve section has various connections **360**, **362**, **364**.

[0066] The flexshaft **316** is then connected to a centralizer **310** to remove the eccentric motion of the rotor **246** before it reaches the valve assembly. The flexshaft **316** is also connected to the rotary valve holder **312** and rotary valve plate **324** which are defined by having a separate opening for each of the flow paths.

[0067] The housing **302** then contains an outer flow restrictor **322** which forms a mud lubricated journal bearing surface with the centralizer **310**. Additionally, the stationary valve holder **326** and stationary valve plate **314** are pressed into the housing behind the outer flow restrictor **322**. The rotary valve may have a portion that is always open through a full rotation relative to the stationary component. The stationary valve plate **314** and the rotary valve plate **324** have a through bore that is a continuation of the flexshaft through bore **350** that is always aligned regardless of the relative angle of the two plates. Various designs of rotary and stationary valve plates can be used. The specific layout of ports and/or the valve can vary depending on the tool design and the particular application.

[0068] The stationary **314** valve plate and rotary valve plate **324** also have one or multiple openings in line with the outer flow path **352** that will come into and out of alignment depending on the relative angle of the plates. It is generally advantageous to always have some percentage of the path open to prevent total cut-off of the flow through the outer flow path **352**. As these plates rotate a variable pressure signal will be created that in combination with a responsive device (such as a shock tool) will impart an axial vibration to the drill string.

[0069] In this manner, the rotor **246** operates as a rotary driving device that converts fluid pressure to rotary motion. The rotary valve **324** has one or more openings connected to the rotary driving device and a stationary component **314** with one or more openings, and the rotation of the rotary valve varies alignment of the one or more openings of the rotary component relative to the one or more openings of the stationary component thereby varying flow through the rotary valve. There is a bypass passage **350** defining a flow path through the rotary valve and the rotor itself. The flow through the bypass passage is independent of the rotation of the rotor. An electrically activated assembly may be used to operate a bypass valve to vary an amount of flow through the bypass passage. The bypass valve may have various configurations and may be actuated electronically.

[0070] The processor may move the bypass valve in response to a measured parameter detected by the sensor reaching a pre-set value. The rotary driving device can be a device other than a rotor operating based on the principles of a Moineau pump. In other embodiments, the rotary driving device may be a turbine.

[0071] FIG. **12** shows the relative pressure drop of the tool shown in the embodiments in FIGS. **6-11** in the activated (upper line) and non-activated (lower line) states versus the relative angle of the rotary and stationary valve plates.

[0072] In the non-activated state, as the valve rotates it still produces a slight pressure pulse, but it is very minor compared with the activated pressure pulse (˜6.5× less). As the area of the through bore is increased relative to the valve opening, the "off" pressure pulse will be reduced.

[0073] Throughout this patent document, the term "activated" refers to a friction-reducing vibration tool in a mode where a significant amount of vibrations are generated. The term "deactivated" refers to a friction-reducing vibration tool in a mode where the vibrations generated by the tool are minimal or non-existent. It will be understood by the person skilled in the art that even when a vibration tool is 'deactivated' that some amount of vibrations will still be generated, particularly because it is generally desirable that there is always some amount of flow through the rotary and stationary components of a valve in a vibration tool so that the valve does not get stuck in a non-flow position. In many cases, the vibration tool will be used in combination with a shock tool and the vibrations generated by the vibration tool will generate less force than is necessary to load the shock tool. That is, many shock tools have a set preload, so that the shock tool will not travel unless the force applied on it exceeds the preload value. If the shock tool preload can be set to a greater value than the non-activated pressure pulse will produce on the tool, then no vibration will be created in the "off" or "deactivated" position.

[0074] FIGS. **13** and **14** shows an embodiment of an electronics assembly which uses a turbine **400** to create power for the electronics assembly. The remaining components of the system may be the same as shown in other embodiments.

[0075] In yet another embodiment there is a downhole valve and activation and deactivation system including a housing that separates the standpipe flow from the annulus flow. A valve body separates the standpipe flow into two or more flow paths. A valve poppet is received by the valve body in order to alter or modify at least one of the flow paths. There is a linear activation system composed of an electric motor and a ball screw. A sensor measures external stimuli and activates/deactivates the system. A battery powers the sensor and linear activation system. The valve body may be made of a hardened material to prevent or limit wash. The valve poppet may be made of a hardened material to prevent or limit wash. The linear activation system may have a gear box between the electric motor and ball screw to increase the available closing force. The sensor may be one or more of: an accelerometer set up to measure inclination, a magnetometer set up to measure inclination, a pressure sensor that measures annulus pressure, a pressure sensor that measures standpipe pressure, and a thermocouple and measures temperature.

[0076] In another there is a downhole valve and embodiment activation/deactivation system for modifying the fluid flow around a power section having a housing that separates the standpipe flow from the annulus flow. A valve body separates the standpipe flow into two paths. The first path is between the rotor and stator of the power section. The second path is through the bore in the rotor.

A valve poppet is receivable by the valve body in order to block the second fluid path. A linear activation system includes an electric motor and a ball screw. A sensor measures external stimuli and activates/deactivates the system. A battery powers the sensor and linear activation system. The valve body is made of a hardened material to prevent or limit wash. The valve poppet may be made of a hardened material to prevent or limit wash. The linear activation system may have a gear box between the electric motor and ball screw to increase the available closing force. The sensor may be one or more of: an accelerometer that is set up to measure inclination, a magnetometer that is set up to measure inclination, a pressure sensor that measures annulus pressure, a pressure sensor that measures standpipe pressure, and a thermocouple and measures temperature. The normal position of the valve poppet may be “closed” and the system “opens” the secondary flow path when activated.

[0077] In yet another embodiment there is disclosed an activation system for a downhole valve. A rotary driving device converts fluid pressure to rotary motion. There is a valve composed of a rotary component with one or multiple openings and a stationary component with one or multiple openings that will align with the rotary openings for at least a partial rotation of the rotary component relative to the stationary component, thereby varying the total flow area throughout the rotation. A bypass passage extends around or through said valve and said rotary driving device. There is a means for substantially plugging said bypass passage. An electrically activated assembly is capable of both plugging and unplugging said bypass. A sensor initiates the activation in response to a measured parameter reaching a pre-set value. The rotary driving device may operate based on the principles of a Moineau pump. The rotary driving device may be a turbine. The valve may have a portion that is always open, regardless of the relative positions of the stationary and rotary components. The electrically activated assembly may be in the form of an electric motor coupled to a ball screw to create linear motion. The means to plug the bypass passage may be in the form of a poppet valve. The means to plug the bypass passage may be rotating a plate relative to a second plate to modify the available flow passages. The sensor may be one or more of: an inclination sensor in the form of an accelerometer, an inclination sensor in the form of a magnetometer, a flow sensor measuring the flow rate, a pressure sensor that is measuring the annulus pressure, and a pressure sensor that is measuring the standpipe pressure.

[0078] In yet another embodiment there is an activation system for a downhole valve including a rotary driving device, a rotary valve, a bypass passage around or through said valve, a means for substantially plugging said bypass passage, and an electrically activated assembly capable of plugging said bypass. A sensor initiates the activation in response to a measured parameter reaching a pre-set value. The rotary driving device may be a Moineau pump. The rotary driving device may be a turbine. The valve may have a portion that is always open, regardless of the relative positions of the stationary and rotary components. The sensor may be one or more of: an inclination sensor in the form of an accelerometer, an inclination sensor in the form of a magnetometer, a flow sensor measuring the flow rate, a pressure sensor that is measuring the annulus pressure, and a pressure sensor that is measuring the standpipe pressure.

[0079] In yet another embodiment there is disclosed the use of an electro-magnetic (EM) signal to initiate the activation. There is an activation system for a downhole valve. The activation system includes a rotary driving device, a rotary valve, a bypass passage around or through said valve, a means for substantially blocking said bypass passage, an electrically driven activation device for said means of substantially blocking said passage, and a means to receive an activation command through an electro-magnetic signal. This embodiment may use RFID tags.

[0080] FIG. **15** shows a schematic of a well profile with multiple downhole tools **500** each including a friction-reducing vibration tool in a drill string **522**. At surface is a drilling rig **524** which includes various surface equipment. At the downhole end of the drill string **522** is the drill bit **530**. Various other pieces of downhole equipment may be present within the drill string, including measurement while drilling (MWD) tools, the drilling motor and other equipment. The surface equipment includes a control signal generator **526**, which may be a standard surface pump or other device which can generate one or more signals which can be detected downhole. Multiple on-demand downhole tools **500** each including a friction-reducing vibration tool may be used in the drill string during drilling. Each of the friction-reducing vibration tools can be activated and deactivated on demand. For example, in the example shown, only the two friction-reducing vibration tools that are in the horizontal section of the well bore may be in the active position. The friction-reducing vibration tool in the vertical section of the wellbore may be deactivated. In other embodiments, all of the friction-reducing vibration tools can be activated or deactivated collectively.

[0081] In most cases, it is the operator of the drilling rig who would determine when it wants to send the signals to activate or deactivate the vibration tool based on the drilling program. This would generally be done by varying the pumps on the rig or rotating the top drive. One benefit of a 'group off' command sent to all vibration tools simultaneously is that in deep lateral wells the multiple vibration tools create pressure pulse noise. Shutting all of the vibration tools off at once can be beneficial for reading MWD signals at depth to reduce noise. All of the vibration tools could then be activated after the MWD signals are processed and the operator will continue drilling.

[0082] FIG. **16** is a schematic of a downhole tool **500** for use in a drill string including a friction-reducing vibration tool and a bypass control. As shown in FIG. **15**, one or more of the downhole tools **500** may be installed in a drill string during drilling. The downhole tool **500** includes a friction-reducing vibration tool, which includes a rotary driving device **508**, **510** which is responsive to fluid flow in the drill string. For example, the rotary driving device may be a Moineau-style rotor **510** within a stator **508** as shown in FIG. **10**. Alternatively, the rotary driving device may be a turbine as shown in FIG. **14**. The friction-reducing vibrating tool includes a valve **520** having a rotary component **516** and a stationary component **518** configured to rotate relative to each other to vary flow through the valve. The rotary component **516** and stationary component **518** may have various configurations and orientations, including rotating relative to each other in which one component sits within the other component and one rotates around the other, or in which the two components face each other and the rotary components rotates around the central axis of the drilling string and the stationary component is fixed relative to the axis of the drill string. The faces of the valves may have various configurations. The rotary and stationary components may have various different designs of one or more openings that may pass in and out of alignment as the components rotate relative to each other. In general, there will always be some flow through the valve components regardless of the relative rotational positions of the components. The rotary component of the valve is driven by the rotary driving device **510**.

[0083] As shown in FIG. **16**, a bypass passage **512** extends around or through one or more of the rotary driving device **508** and the valve **520**. In the embodiment shown in FIG. **16**, the bypass passage **512** extends through the rotor **510** of the Moineau-style rotor, through a flex shaft **514** and into the valve **520**. In other embodiments, the bypass passage may extend only through the rotary driving device **508**, or only through the valve **520**. In the case that the bypass passage extends only though the rotary driving device **508**, then the speed of rotation of the valve can be controlled by the amount of fluid that passes through the bypass passage in contrast to the amount of fluid that passes through the rotor. In the case that the bypass passage extends only through the valve **520**, then the amount of vibrations generated by the friction-reducing vibration device will be controlled by the amount of fluid that bypasses the valve and does not pass through the openings that vary as the rotary and stationary components rotate relative to each other.

[0084] There is a bypass control that includes a sensor **502** for detecting a stimulus, a bypass actuator **506** for controlling an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor **504** in communication with the sensor **502** to control the bypass actuator **506** in response to signals from the sensor indicative of the stimulus being detected. The bypass control may include a battery connected to the sensor and

the processor.
[0085] As described elsewhere in this patent application, the stimulus may be a condition downhole. For example, the detected stimulus may be a condition indicative that the drill string is in a horizontal section of a well. In that case, the bypass control may be programmed to activate the friction-reducing vibration tool in response to the sensor detecting that the drill string is in the horizontal section of the well. Similarly, the detected stimulus may be a condition indicative that the drilling string is in a vertical section of the well. In that case, the bypass control may be programmed to deactivate the friction-reducing vibration tool in response to the sensor detecting that the drill string is in the vertical section of the well.
[0086] The sensor can detect conditions downhole by detecting inclination angles of the tool or by detecting depth based on hydrostatic pressure.
[0087] In other embodiments, the stimulus is a control signal received from surface. For example, the control signal may be a series of timed pump cycles, a series of timed rotary cycles, or a variation in pressure cycles. More generally, the control signal may be any electronic or fluid property which can be transmitted downhole from the surface. Any type of variation in fluid pressure or rate that is detectable downhole can be used to generate a signal for the bypass control. The functionality created by the control signal generator may be merely programing added to a pre-existing device at surface. For example, a standard mud pump may be programmed to generate control signals which can be detected by the bypass control. The decision when to activate the one or more friction-reducing vibration tools may be determined based on pre-calculated properties of the expected drilling operation or based on conditions that are detected downhole by one or more sensors, including the MWD. The decision when to activate the vibration tools may depend on various factors, including the number of vibration tools in the drill string and the distances between them. Different operators may have different preferences for the timing of activating each of the vibration tools. In some cases, it may only be necessary to activate the vibration tools when the drill string extends through a pre-determined length of a horizontal section of the wellbore.
[0088] Various designs as disclosed herein may be used as the bypass actuator. For example, the bypass actuator may be an electric motor and a ball screw as shown in the embodiment in FIGS. **7-9**. The bypass actuator may be a valve poppet as shown in the embodiment shown in FIGS. **1-3** that is axially moveable to vary the amount of fluid flow through the bypass passage. In some embodiments, the bypass can be closed by a rotary valve actuator. For instance, instead of the electronics turning a ball screw to axially move a poppet, the electric motor could turn a plate valve from open to close or vice versa.
[0089] The sensor may be one or more of: an accelerometer, a magnetometer, a pressure sensor or a thermocouple.
[0090] Embodiments of the friction-reducing vibration tools described herein may be activated or deactivated downhole. A stimulus is detected using a sensor. The friction-reducing vibration tool is electrically activated or deactivated in response to signals from the sensor indicative of the stimulus being detected. In some embodiments, as described above, a control signal is generated from surface to active or deactivate the friction-reducing vibration tool. The control signal may be transmitted downhole, for example, through operation of the control signal generator, wherein the control signal is the stimulus. A plurality of friction-reducing vibration tools may be activated or deactivated in a drill string at the same time using the same control signal.
[0091] As shown in FIG. **16**, the friction-reducing vibration tool may include a rotary driving device responsive to fluid flow in the drill string, a valve includes a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device, and a bypass passage around or through one or more of the rotary driving device and the valve, and wherein electrically activating or deactivating the friction-reducing vibration tool comprises activating or deactivating a bypass control to vary the flow through the bypass passage.

[0092] A bypass actuator controls an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor indicative of the stimulus being detected.

[0093] FIGS. **17** and **18** show a downhole tool **600** including a friction-reducing vibration tool in which the actuator assembly is below the rotary valve to remove any need for the stationary orifice **254** (FIG. **10**) that forms the stationary to rotary interface with the rotor **246** (FIG. **10**). On the uphole end of the tool **600** is a shock tool **632** (FIG. **17**A). Below the shock tool is the power section of the vibration tool (FIG. **17**B), which includes a stator **608** and a rotor **610**. A bypass passage **612** extends through the rotor **610**. A flex shaft **614** connects between the rotor **610** and the rotary component **616** of the valve. Each of the flex shaft **614** and the valve include the bypass passage **612**. The valve includes the rotary component **616** (FIG. **17**C) and the stationary component **618**. The portions of the rotary component **616** and the stationary component **618** which are in face-to-face contact may be carbide inserts, including a rotary carbide face **634** and a stationary carbide face **636**. The stationary component **618** of the valve is connected to a poppet **606** which operates to open and close a bypass opening **646** (FIG. **18**B). The opening and closing of the bypass opening **646** will vary the amount of fluid flow through the bypass passage **612**. The poppet **606** is actuated by an electric motor **640** (FIG. **18**B) which drives a gear box **638** which in turn moves the poppet **606** via a ball screw **648**. Collectively, the electric motor **640**, the gear box **638**, the ball screw **648** and the poppet **606** form a bypass actuator. The control for the bypass actuator is provided by a circuit board **604** (FIG. **18**C) which contains both a processor and a sensor. Between the electric motor **640** and the circuit board **604** there is a snubber **642** (FIG. **18**B) for absorbing axial vibration. Downhole of the circuit board **604** is a battery **644** (FIG. **18**C). Collectively, the battery **644**, the circuit board **604**, the snubber **642**, the electric motor **640**, the gear box **638**, the ball screw **648** and the poppet **606** form a bypass control.

[0094] FIG. **18** shows a close-up view of the downhole tool of FIG. **17**. This shows the bypass opening **646** (FIG. **18**B) more clearly. The fluid flow through the drill string will go through the valve and rotor in the off position. At the poppet **606** there are three bypass openings **646** or ports to return the flow together into the annulus where it will flow around the electronics. Any number or shape of ports may be used so long as sufficient flow may be directed through the bypass passage to functionally deactivate the vibration tool. When the poppet **606** closes the bypass openings **646**, all flow goes through the valve and then around the electronics. When the poppet **606** opens the bypass openings, then some amount of fluid flow will be directed through the center of the rotor and through the center of the valve, which functionally shifts the vibration tool into the deactivated position whereby the vibration of the tool is significantly diminished.

[0095] In the claims, the word “comprising” is used in its inclusive sense and does not exclude other elements being present. The indefinite articles “a” and “an” before a claim feature do not exclude more than one of the feature being present. Each one of the individual features described here may be used in one or more embodiments and is not, by virtue only of being described here, to be construed as essential to all embodiments as defined by the claims.

Claims

1. A downhole tool for use in a drill string, comprising: a friction-reducing vibration tool, comprising: a rotary driving device responsive to fluid flow in the drill string, a valve including a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device, and a bypass passage around or through one or more of the rotary driving device and the valve; and a bypass control, comprising: a sensor for detecting a stimulus, a bypass actuator for controlling an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor indicative of the stimulus being detected.

2. The downhole tool of claim 1 wherein the stimulus is a condition downhole.

3. The downhole tool of claim 1 wherein the stimulus is a control signal received from surface.

4. The downhole tool of claim 3 wherein the control signal is a series of timed pump cycles.

5. The downhole tool of claim 3 wherein the control signal is a series of timed rotary cycles.

6. The downhole tool of claim 3 wherein the control signal is a variation in pressure cycles.

7. The downhole tool of claim 1 wherein the rotary driving device is a Moineau-style rotor within a stator.

8. The downhole tool of claim 1 wherein the bypass actuator further comprises an electric motor and a ball screw.

9. The downhole tool of claim 1 wherein the bypass actuator further comprises a valve poppet that is axially moveable to vary the amount of fluid flow through the bypass passage.

10. The downhole tool of claim 1 wherein the sensor is one or more of: an accelerometer, a magnetometer, a pressure sensor or a thermocouple.

11. A method of activating or deactivating a friction-reducing vibration tool in a drill string, the method comprising: detecting a stimulus using a sensor; and electrically activating or deactivating the friction-reducing vibration tool in response to signals from the sensor indicative of the stimulus being detected.

12. The method of claim 11 further comprising: generating a control signal from surface; and transmitting the control signal downhole, wherein the control signal is the stimulus.

13. The method of claim 12 further comprising activating or deactivating a plurality of friction-reducing vibration tools in a drill string at the same time using the control signal.

14. The method of claim 11 wherein the friction-reducing vibration tool comprises: a rotary driving device responsive to fluid flow in the drill string; a valve including a rotary component and a stationary component configured to rotate relative to each other to vary flow through the valve, the rotary component of the valve driven by the rotary driving device; and a bypass passage around or through one or more of the rotary driving device and the valve; and wherein electrically activating or deactivating the friction-reducing vibration tool comprises activating or deactivating a bypass control to vary the flow through the bypass passage.

15. The method of claim 11 wherein the stimulus is a condition downhole.

16. The method of claim 12 wherein the control signal is a series of timed pump cycles.

17. The method of claim 12 wherein the control signal is a series of timed rotary cycles.

18. The method of claim 12 wherein the control signal is a variation in pressure cycles.

19. The method of claim 14 wherein the bypass control comprises: the sensor, a bypass actuator for controlling an amount of fluid flow through the bypass passage to activate or deactivate the friction-reducing vibration tool, and a processor in communication with the sensor to control the bypass actuator in response to signals from the sensor indicative of the stimulus being detected.
