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(54) **SENSORED ELECTRONIC VALVE FOR DRILLING AND WORKOVER APPLICATIONS**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,706,933 A	11/1987	Sukup et al.
5,310,005 A	5/1994	Dollison
6,125,930 A	10/2000	Moyes
6,450,258 B2	9/2002	Green et al.

(Continued)

FOREIGN PATENT DOCUMENTS

GB	2443374 A	4/2008
GB	2444194 A	5/2008

(Continued)

OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT Application No. PCT/US2021/044823 dated Oct. 21, 2021.

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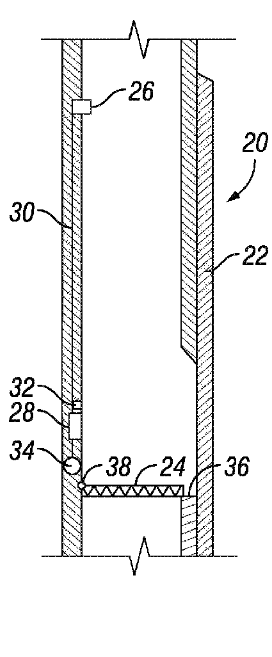
(57) **ABSTRACT**

Systems and methods for controlling a flow of fluid within a subterranean well includes a sensored electronic valve assembly having a one way valve member operable to allow a flow of fluids in a first direction through the one way valve member and to prevent the flow of fluids in a second direction through the one way valve member. An electronic circuit includes a battery having a battery life of a predetermined time and a command center. A sensor can detect a valve open signal and to deliver the valve open signal to the command center. An opening device is operable to move the one way valve member to a valve open position upon receipt of an engagement signal from the command center. The opening device is inoperable after the predetermined time. The one way valve member is operable to function as a one way valve after the predetermined time.

17 Claims, 2 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

6,666,271	B2	12/2003	Deaton et al.	
6,684,950	B2	2/2004	Patel	
6,926,089	B2	8/2005	Goodson, Jr. et al.	
7,086,481	B2	8/2006	Hosie et al.	
7,252,152	B2	8/2007	Logiudice et al.	
7,789,156	B2	9/2010	Pia	
8,464,799	B2	6/2013	Scott et al.	
9,163,479	B2	10/2015	Rogers et al.	
10,088,064	B2	10/2018	Churchill	
2005/0230118	A1	10/2005	Noske et al.	
2008/0053662	A1*	3/2008	Williamson	E21B 34/066 166/381
2012/0067594	A1*	3/2012	Noske	E21B 34/08 166/373
2013/0048290	A1	2/2013	Howell et al.	
2013/0206389	A1*	8/2013	Vick, Jr.	E21B 34/101 166/105
2014/0202768	A1*	7/2014	Noske	E21B 34/14 175/57
2016/0177673	A1	6/2016	Merron et al.	
2017/0218722	A1*	8/2017	Gordon	E21B 33/134
2017/0247960	A1*	8/2017	Kyle	E21B 34/066
2017/0248009	A1*	8/2017	Fripp	E21B 33/10
2019/0128098	A1	5/2019	Ross et al.	
2020/0141211	A1*	5/2020	Franklin	E21B 34/14
2020/0141506	A1*	5/2020	Holder	F16K 17/30
2020/0347699	A1*	11/2020	Coates	E21B 34/16

FOREIGN PATENT DOCUMENTS

WO	2013006159	A1	10/2013
WO	2019112579	A1	6/2019

* cited by examiner

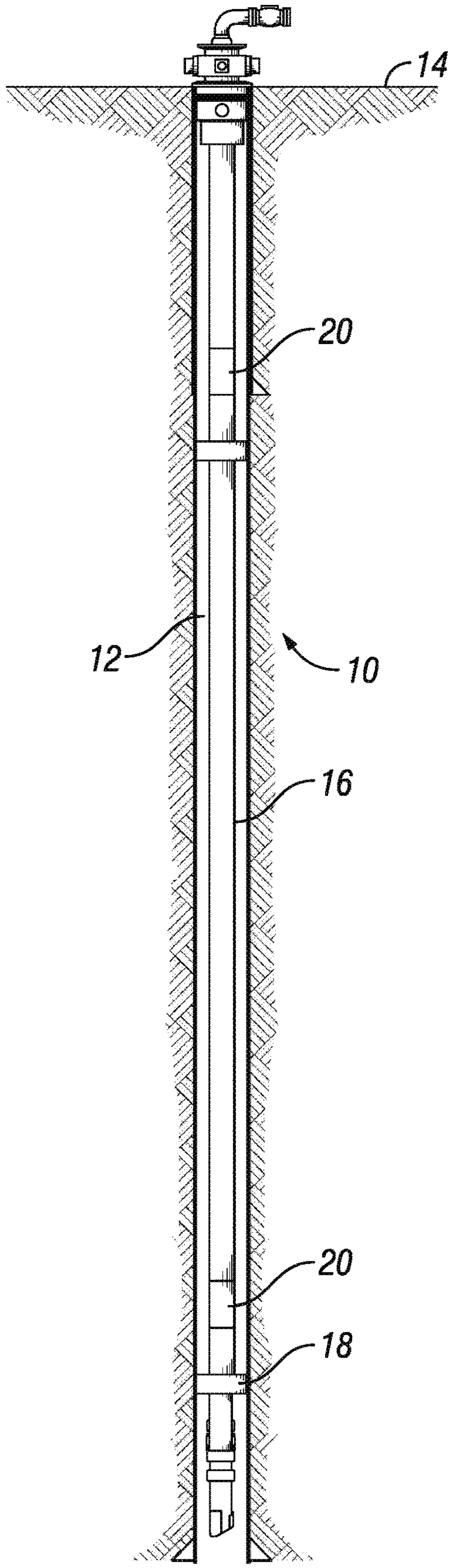


FIG. 1

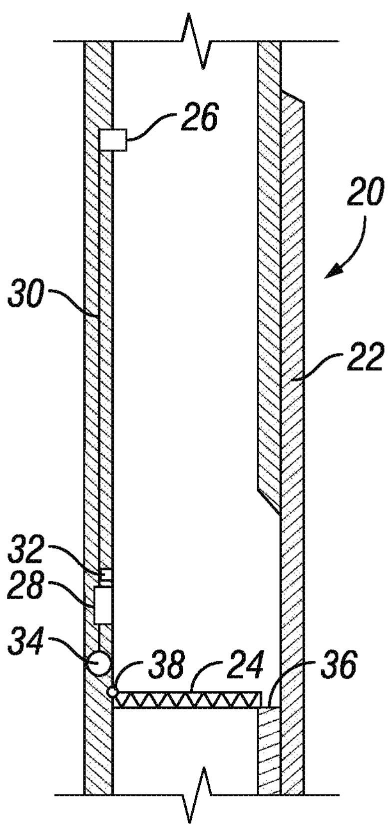


FIG. 2

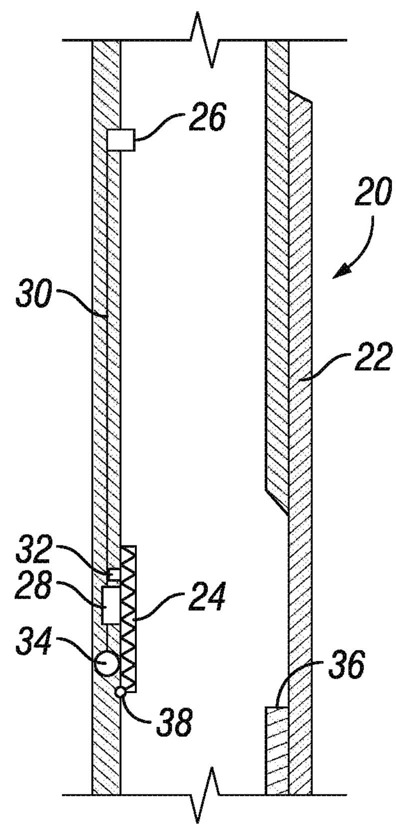


FIG. 3

SENSORED ELECTRONIC VALVE FOR DRILLING AND WORKOVER APPLICATIONS

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

The present disclosure relates to subterranean well development, and more specifically, the disclosure relates to valves used within tubular members and non-tubular members of subterranean wells.

2. Description of the Related Art

Several types of valves are used in downhole drilling or completion assemblies in hydrocarbon wells. These valves allow fluid flow or stop fluid flow either in one or both directions, as required for the application and objectives of the operation. The valves in some cases compartmentalizes the well bore in order to create specialized treatments for different sections of a wellbore

Drilling and completion operations in hydrocarbon wells require several downhole equipment assemblies. Downhole valves are important parts of certain downhole equipment assemblies. Commonly used downhole valves include float valves, spring loaded check valves, flapper valves, ball valves, drop in check valves, and multi-activation circulating valves. In fracking or stimulation operations ball seats with different size balls are used to stop fluid flow in certain direction and to direct fluid to a certain part of the well bore. These downhole valves are used in different circumstances to meet safety and operational objectives of subterranean wells. Other devices, which are also used downhole for providing fluid flow isolation include ceramic discs or mechanically controlled inflow valves. These devices act as permanent installations in the tubular string and allow the flow of fluid only when either broken or shifted open through an intervention tool.

SUMMARY OF THE DISCLOSURE

Systems and methods of this disclosure provide a sensored electronic valve that allows the flexibility to open and close the valve member by activating a sensor as, and when, the flow of fluid or equipment access through the valve member is required. The opening and closing of the valve member can be accomplished using a battery powered closed loop electronic system. Embodiments of this disclosure provide systems and methods that allow for safe and stable conditions downhole with a one way valve, while including the ability to override the normal functioning of the valve when there is an operational need. This valve design can be used for a variety of applications related to the control of fluid flows in the wellbore. The sensored electronic valve can convert to traditional functioning one way valve after the intervention requirements have been completed.

In an embodiment of this disclosure a system for controlling a flow of fluid within a subterranean well with a sensored electronic valve assembly is disclosed. The system includes the sensored electronic valve assembly having a one way valve member operable to allow a flow of fluids in a first direction through the one way valve member and to prevent the flow of fluids in a second direction through the one way valve member. An electronic circuit includes a battery and a command center, the battery having a battery life of a predetermined time. A sensor is operable to detect a valve open signal and to deliver the valve open signal to the command center. An opening device is operable to move the one way valve member to a valve open position upon receipt of an engagement signal from the command center. The opening device is inoperable after the predetermined time. The one way valve member is operable to function as a one way valve after the predetermined time. Alternatively, a solenoid can be used which generates electric current as a magnetized chip pass through it. The electric current will activate the command center to operate the flapper valve.

In alternate embodiments, the sensored electronic valve assembly can be part of a completion system and located within a tubular string. The valve member can be removable. The command center can include a data processor and a signal transmitter. The opening device can be a motor. Alternately, the opening device can be an electromagnet.

In other alternate embodiments, the valve open signal can be a proximity of an intervention tool. The one way valve member can be a normal closed valve and the sensor can be further operable to detect a valve open signal and to deliver the valve open signal to the command center. The opening device can be operable to disengage the one way valve member to allow the one way valve member to return to a normal closed position upon receipt of a disengagement signal from the command center.

In an alternate embodiment of this disclosure, a system for controlling a flow of fluid within a subterranean well includes a sensored electronic valve assembly. The system further includes a tubular string extending into the subterranean well, the tubular string having an internal bore for transportation of fluid between an earth's surface and a downhole location within the subterranean well. The sensored electronic valve assembly is located along the tubular string. The sensored electronic valve assembly has a one way valve member operable to allow a flow of fluids within the tubular string in a first direction through the one way valve member and to prevent the flow of fluids within the tubular string in a second direction through the one way valve member. A battery has a battery life of a predetermined time. A sensor is operable to detect a valve open signal. An opening device is operable to move the one way valve member to a valve open position after receipt of the valve open signal by the sensor. The opening device is inoperable after the predetermined time. The one way valve member is operable to function as a one way valve after the predetermined time.

In alternate embodiments, the system can further include a command center and the command center can be operable to receive the valve open signal detected by the sensor and to deliver an engagement signal to the opening device. The sensored electronic valve assembly can further include a valve body, the valve body housing the one way valve member and being secured in-line along the tubular string.

In another alternate embodiment of this disclosure, a method for controlling a flow of fluid within a subterranean well with a sensored electronic valve assembly includes delivering the sensored electronic valve assembly into the subterranean well. The sensored electronic valve assembly has a one way valve member operable to allow a flow of fluids in a first direction through the one way valve member and to prevent the flow of fluids in a second direction through the one way valve member. An electronic circuit includes a battery and a command center. The battery has a battery life of a predetermined time. The sensored electronic valve assembly further includes a sensor and an opening device. The opening device is inoperable after the predetermined time. The one way valve member is operable to function as a one way valve after the predetermined time. The method further includes delivering a valve open signal into the subterranean well. The valve open signal is received by the sensor and is delivered to the command center by the sensor. An engagement signal is delivered from the command center to the opening device, causing the opening device to move the one way valve member to a valve open position.

In alternate embodiments, delivering the sensored electronic valve assembly into the subterranean well can include delivering the sensored electronic valve assembly into the subterranean well within a tubular string as part of a completion system. The method can further include removing the valve member from the subterranean well while the tubular string remains within the subterranean well. The command center can include a data processor and a signal transmitter and the method can further include processing the valve open signal with the data processor and delivering the engagement signal from the command center to the opening device with the signal transmitter.

In other alternate embodiments, the opening device can be a motor and the method can further include moving the one way valve member to the valve open position and retaining the one way valve member in the valve open position with the motor. Alternately, the opening device can be an electromagnet and the method can further include moving the one way valve member to the valve open position and retaining the one way valve member in the valve open position with the electromagnet.

In yet other alternate embodiments, delivering the valve open signal into the subterranean well can include moving an intervention tool proximate to the sensored electronic valve assembly. The one way valve member can be a normal closed valve and the method can further include detecting a valve close signal with the sensor and delivering the valve close signal to the command center. The opening device can be operable to disengage the one way valve member to allow the one way valve member to return to a normal closed position upon receipt of a disengagement signal from the command center.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the features, aspects and advantages of the embodiments of this disclosure, as well as others that will become apparent, are attained and can be understood in detail, a more particular description of the disclosure may be had by reference to the embodiments thereof that are illustrated in the drawings that form a part of this specification. It is to be noted, however, that the appended drawings illustrate only certain embodiments of the disclosure and are, therefore, not to be considered limiting of the disclosure's scope, for the disclosure may admit to other equally effective embodiments.

FIG. **1** is a schematic section view of a subterranean well with a sensored electronic valve, in accordance with an embodiment of this disclosure.

FIG. **2** is a schematic section view of a sensored electronic valve, in accordance with an embodiment of this disclosure, with the sensored electronic valve shown in a closed position.

FIG. **3** is a schematic section view of a sensored electronic valve, in accordance with an embodiment of this disclosure, with the sensored electronic valve shown in an open position.

DETAILED DESCRIPTION

The disclosure refers to particular features, including process or method steps. Those of skill in the art understand that the disclosure is not limited to or by the description of embodiments given in the specification. The subject matter of this disclosure is not restricted except only in the spirit of the specification and appended Claims.

Those of skill in the art also understand that the terminology used for describing particular embodiments does not limit the scope or breadth of the embodiments of the disclosure. In interpreting the specification and appended Claims, all terms should be interpreted in the broadest possible manner consistent with the context of each term. All technical and scientific terms used in the specification and appended Claims have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs unless defined otherwise.

As used in the Specification and appended Claims, the singular forms “a”, “an”, and “the” include plural references unless the context clearly indicates otherwise.

As used, the words “comprise,” “has,” “includes”, and all other grammatical variations are each intended to have an open, non-limiting meaning that does not exclude additional elements, components or steps. Embodiments of the present disclosure may suitably “comprise”, “consist” or “consist essentially of” the limiting features disclosed, and may be practiced in the absence of a limiting feature not disclosed. For example, it can be recognized by those skilled in the art that certain steps can be combined into a single step.

Where a range of values is provided in the Specification or in the appended Claims, it is understood that the interval encompasses each intervening value between the upper limit and the lower limit as well as the upper limit and the lower limit. The disclosure encompasses and bounds smaller ranges of the interval subject to any specific exclusion provided.

As used in this Specification, the term “substantially equal” means that the values being referenced have a difference of no more than two percent of the larger of the values being referenced.

Where reference is made in the specification and appended Claims to a method comprising two or more defined steps, the defined steps can be carried out in any order or simultaneously except where the context excludes that possibility.

Looking at FIG. **1**, subterranean well **10** can have wellbore **12** that extends to an earth's surface **14**. Subterranean well **10** can be an offshore well or a land based well and can be used for producing hydrocarbons or other fluids from subterranean hydrocarbon reservoirs. Wellbore **12** can be drilled from surface **14** and into and through various subterranean formations. In the example of FIG. **1**, wellbore **12** extends generally vertically relative to the earth's surface **14**. In alternate embodiments, at least a portion of wellbore **12** can be a horizontal well that extends generally horizontally relative to the earth's surface **14**, or can be an inclined well that extends at another angle relative to earth's surface **14**.

A tubular string **16**, such as a completion, multi stage fracturing assembly, or production string can be used to deliver the fluids from the hydrocarbon reservoir to the surface. Tubular string **16** can be formed of a series of tubular pipe joints that are secured end to end. Tubular string **16** can have an internal bore for the transportation of fluid between earth's surface **14** and a downhole location within subterranean well **10**. Tubular string **16** can include a lower isolation assembly **18**. Lower isolation assembly **18** can engage an inner diameter surface of wellbore **12** so that lower isolation assembly **18** seals the space between tubular string **16** and wellbore **12**. Tubular string **16** can include additional isolation assemblies along the length of tubular string **16**.

Tubular string **16** can further include one or more sensored electronic valve assemblies **20**. Sensored electronic valve assembly **20** is secured in-line with adjacent tubular pipe joints of tubular string **16**. As an example, sensored electronic valve assembly **20** can be threaded to adjacent tubular pipe joints to form tubular string **16**. Sensored electronic valve assembly **20** can be used to control the flow of fluid within subterranean well **10**. In particular, sensored electronic valve assembly **20** can be used to control the flow of fluid within tubular string **16**. In the example embodiment of FIG. **1**, sensored electronic valve assembly **20** is part of a completion system and located along a production tubular. In alternate embodiments, sensored electronic valve assembly **20** can be part of a drilling string or an alternate type of tubular string that is utilized within a subterranean well.

Looking at FIGS. **2-3**, sensored electronic valve assembly **20** includes valve body **22**, which is a generally elongated tubular member. Valve body **22** is secured in-line along tubular string **16**. Valve body **22** houses the other components of sensored electronic valve assembly **20**.

Sensored electronic valve assembly **20** includes one way valve member **24**. In the example embodiments, one way valve member **24** is shown as a flapper valve. In alternate embodiments, one way valve member **24** can be a ball valve, a spring loaded valve, or an alternate type of valve that allows for a flow of fluid in one direction. Although embodiments of this disclosure include the example of a one way valve member, other embodiments could alternately include a two way valve which can perform the same functions as the one way valve member described in this disclosure.

As shown in the example embodiments, one way valve member **24** will allow for a flow of fluid in an uphole direction through sensored electronic valve assembly **20**, and can prevent the flow of fluid in a downhole direction through sensored electronic valve assembly **20**.

There may be times when it is desirable for one way valve member **24** to allow for the passage of fluid, tools, or other equipment to move through sensored electronic valve assembly **20** in both directions. In such a case, one way valve member **24** can be moved and maintained in an open position by operator instruction, as shown in FIG. **3**.

Sensor **26** can be used to detect a valve open signal. Sensor **26** can be located uphole of one way valve member **24**. In alternate embodiments, sensor **26** can be located downhole of one way valve member **24** or at the elevation of one way valve member **24**. The location of sensor **26** will be dependent on the type of sensor used and the method of providing the valve open signal to sensor **26**.

Sensor **26** can be triggered, as an example, by a metallic intervention tool, a tubular member, a cable, a wireline, an e-line, a slick line, or a digital slick line that moves proximate to or past sensor **26** in a downhole direction. Even a partial break or obstruction of the sensors by such a trigger can be interpreted as a valve open signal. In alternate embodiments, sensor **26** can detect a radio frequency identification signal, a magnetic signal, an acoustic signal, a specific flowrate or a specific change in flow rate, a specific pressure or a change in pressure, or a specific temperature or a change in temperature signature as the valve open signal.

As a further example, sensor **26** can be a magnetic sensor that is triggered with a series of magnetic signatures. These magnetic values can be installed in a form of magnetized pipes that would trigger the sensor if read in the correct sequence during the running of the magnetized pipe into the wellbore and if needed, at a pre-determined speed. Alternately, sensor **26** can be a radio frequency identification sensor that is triggered by a pipe containing a radio frequency identification tag. In such examples, the triggering of the sensor is the receipt by the sensor of a valve open signal.

Sensor **26** can communicate to command center **28** that a valve open signal has been received. Sensor **26** can communicate with command center **28** by way of communication wire **30** that runs through a sidewall of valve body **22**.

Command center **28** and sensor **26** can be powered by battery **32**. Command center **28** and battery **32** can be part of an electronic circuit that can control the operation of one way valve member **24**. In embodiments, the electronic circuit can be a smart activating circuit that can be triggered to change the behavior of the valve in terms of timing and pressure holding value. This smart circuit can send information on diagnostics as an example as well as other information including but not limited to battery life and pressure information.

The characteristics of battery **32** will be selected to suit wellbore temperature, wellbore pressure, and the desired battery life. Battery **32** can have a battery life of a predetermined length of time. The battery life of battery **32** can be sufficiently long to enable the electronic circuit to operate one way valve member **24** until the expected well interventions are completed. After the predetermined time has expired and the battery life is over, the electronic circuit will stop working and sensored electronic valve assembly **20** can function as a one way valve, allowing only unidirectional flow through sensored electronic valve assembly **20** without the ability for any further intervention.

In alternate embodiments, a battery charging feature can be included to charge battery **32** downhole using induction. As an example, the induction can be initiated with a magnetic current resulting from magnets that are run into wellbore **12** using an electronic tool. The battery charging feature may be required, for example, if battery **32** is not capable of remaining charged for the predetermined time, or if additional time is required to complete the well intervention operations. In other alternate embodiments, a solenoid can be used which generates electric current as a magnetized chip passes through it. The electric current can activate command center **28** to operate the valve member.

Sensored electronic valve assembly **20** further includes opening device **34**. Opening device **34** can be, for example, a motor, an electromagnet, or another device that is capable of moving one way valve member **24** from the closed position of FIG. **2** to the open position of FIG. **3**, and maintaining one way valve member **24** in the open position. However, after the predetermined time has expired and battery **32** no longer has a charge opening device **34** will be inoperable.

After command center **28** receives the signal from sensor **26** that a valve open signal has been received, a data processor can process the signal from sensor **26**. The command center can then transmit an engagement signal to opening device **34** from a signal transmitter of the command center. Opening device **34** will move one way valve member **24** to the open position and retain one way valve member **24** in the open position after receipt of the engagement signal. As an example, the engagement signal may be the delivery of power to opening device **34** so that opening device **34** can operate to move and retain one way valve member **24** in the open position.

If, for example, opening device **34** is a motor, then one way valve member **24** can be moved from the closed position of FIG. **2** to the open position of FIG. **3** with the motor. The motor can further retain one way valve member **24** in the open position. Alternately, if opening device **34** is an electromagnet, then one way valve member **24** can be moved from the closed position of FIG. **2** to the open position of FIG. **3** with the electromagnet. The electromagnet can be designed to exert enough pull force on one way valve member **24** to pull one way valve member **24** to the open position. The electromagnet can further retain one way valve member **24** in the open position.

One way valve member **24** can be a normal closed valve. In that way, if opening device **34** is not retaining one way valve member **24** in the open position, then one way valve member **24** will return to the normal closed position. Looking at FIG. **2**, in the normal closed position, one way valve member **24**, which is a flapper, is resting on valve stop **36**. Valve stop **36** protrudes radially inward from the sidewall of valve body **22**. The flapper is held in place resting on valve stop **36** by a biasing member **38**. Biasing member **38** can be, for example, a spring. The valve member **24** rests on stop **36** such that it provides a seal and disallows any movement of fluid in the blocked direction.

When opening device **34** receives a disengagement signal from command center **28**, opening device **34** will cease holding one way valve member **24** in the open position of FIG. **3** and biasing member **38** will return one way valve member **24** to the normal closed position.

Command center **28** will deliver the disengagement signal to opening device **34** when sensor **26** received a valve closed signal. The valve close signal can be, as an example, a metallic intervention tool, a tubular member, a cable, a wireline, an e-line, a slick line, or a digital slick line that moves away from or past sensor **26** in an uphole direction. In alternate embodiments, sensor **26** can detect a radio frequency identification signal, a magnetic signal, an acoustic signal, a specific flowrate or a specific change in flow rate, a specific pressure or a change in pressure, or a specific temperature or a change in temperature signature as the valve close signal.

As a one way valve, one way valve member **24** can also be moved to the open position, or at least be moved off of valve stop **36** and into a position somewhere between fully closed and fully open, by a flow of fluid in an uphole direction. The flow of fluid in the uphole direction would be required to exert a sufficient amount of force on one way valve member **24** to overcome the force of biasing member **38**. After the predetermined time has expired and battery **32** no longer has a charge, opening device **34** will be inoperable and one way valve member **24** can continue to function as a traditional one way valve.

In certain embodiments it may be beneficial to further remove one way valve member **24** from subterranean well **10** after the predetermined time has expired and battery **32** no longer has a charge. In such embodiments, one way valve member **24** can be removed from subterranean well **10** while tubular string **16** remains within subterranean well **10**. In such embodiments, one way valve member **24** can be destroyed in place. As an example, one way valve member **24** can be designed to be broken into piece, such as through the use of a breaking tool, coil tubing, or an increased pressure. Alternately, one way valve member **24** can be formed of a material that dissolves over time. In other alternate embodiments, one way valve member **24** can be formed of a material that will dissolve with the delivery of a pre-designed chemical through the bore of tubular string **16**.

In an example of operation, in order to control the flow of fluid within subterranean well **10**, sensored electronic valve assembly **20** can be delivered into subterranean well **10** as part of a tubular string, such as being part of tubular string **16**. One way valve member **24** can be in an open position while tubular string **16** is run into wellbore **12**, allowing a flow of fluid through tubular string **16** in an uphole direction. After the tubular string with sensored electronic valve assembly **20** has reached a desired depth within wellbore **12**, one way valve member **24** will be moved to the normal closed position by biasing member **38**.

A valve open signal can be delivered to sensor **26**. As an example, as the intervention tool or coil tubing for pumping stimulation fluid is run inside a multistage fracturing assembly, sensor **26** will detect the tubing or the intervention tool and interpret as a valve open signal. The valve open signal, having been received by the sensor **26**, is delivered to command center **28** by sensor **26**. Command center **28** can then deliver an engagement signal to opening device, **34**, causing opening device **34** to move one way valve member **24** to the valve open position, and maintain one way valve member **24** in the open position.

After the intervention operation is complete, the intervention tool or coil tubing is pulled above sensor **26**. Sensor **26** can interpret the movement of the intervention tool or coil tubing in a direction uphole as a valve close signal. Sensor **26** can deliver the valve close signal to command center **28**. Command center **28** will in turn deliver a disengagement signal to opening device **34**. Because one way valve member **24** is a normal closed valve, one way valve member can then return to the normal closed position.

In a further example of operation, sensored electronic valve assembly **20** can be used as part of a multi stage fracking and acid stimulation operation. The process of multi stage fracking begins with running a multi stage fracking assembly into the wellbore with packers spaced out along the multistage fracking assembly to isolate several segments of the reservoir. Acid stimulation or fracking is carried out selectively for each isolated reservoir segment one at a time.

A commonly used arrangement is to selectively open the port across selected reservoir segment for pumping stimulation fluid at pre-designed rate and pressure. In some currently available systems and methods, as soon as stimulation fluid is injected, the wellbore starts to lose fluid into the formation. The cumulative losses after several stages of stimulation could create underbalance conditions in the well due to a loss of hydrostatic head. Stabilizing the well requires considerable time before other operations can be safely carried out following Industry standard well control standards.

By including a sensored electronic valve assembly **20** uphole of each isolated reservoir segment, particular sensored electronic valve assemblies **20** can be maintained in an open position during certain steps of the operation and then allowed to return to the normal closed position, isolating the hydrostatic column above sensored electronic valve assembly **20** from the stimulated segment of the reservoir.

Embodiments of this disclosure therefore provides systems and methods for stimulating consecutive segments of a subterranean well, starting downhole and moving in an uphole direction, with reduced or no losses of fluids into the formation. Systems and method described in this disclosure further enhance the safety and control over fluids going in and out of the well bore, save rig time and therefore cost from milling operations and opening and closing runs, and reduces the pressures needed to open and close valves compared to currently available systems.

Embodiments of this disclosure, therefore, are well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others that are inherent. While embodiments of the disclosure has been given for purposes of disclosure, numerous changes exist in the details of procedures for accomplishing the desired results. These and other similar modifications will readily suggest themselves to those skilled in the art, and are intended to be encompassed within the spirit of the present disclosure and the scope of the appended claims.

What is claimed is:

1. A system for controlling a flow of fluid within a subterranean well with a sensored electronic valve assembly, the system including:

a completion system having a tubular string extending into the subterranean well;

the sensored electronic valve assembly located within the tubular string and having:

a one way valve member operable to allow a flow of fluids in an uphole direction through the one way valve member and to prevent the flow of fluids in a downhole direction through the one way valve member;

an electronic circuit including a battery and a command center, the battery having a battery life of a predetermined time;

a sensor operable to detect a valve open signal and to deliver the valve open signal to the command center; and

a battery powered opening device operable to move the one way valve member to a valve open position upon receipt of an engagement signal from the command center within the predetermined time only, the battery powered opening device being inoperable after the predetermined time; where

the one way valve member is operable to function as a one way valve after the predetermined time, allowing the flow of fluids in the uphole direction through the one way valve member when the battery powered opening device is inoperable, so that the one way valve member is a fluid flow path through the tubular string for produced fluids from the subterranean well.

2. The system of claim **1**, where the valve member is removable.

3. The system of claim **1**, where the command center includes a data processor and a signal transmitter.

4. The system of claim **1**, where the battery powered opening device is a motor.

5. The system of claim **1**, where the battery powered opening device is an electromagnet.

6. The system of claim **1**, where the valve open signal is a proximity of an intervention tool.

7. The system of claim **1**, where the one way valve member is a normal closed valve and the sensor is further operable to detect a valve close signal and to deliver the valve close signal to the command center, and where the battery powered opening device is operable to disengage the one way valve member to allow the one way valve member to return to a normal closed position upon receipt of a disengagement signal from the command center.

8. A system for controlling a flow of fluid within a subterranean well with a sensored electronic valve assembly, the system including:

a tubular string extending into the subterranean well, the tubular string having an internal bore for transportation of fluid between an earth's surface and a downhole location within the subterranean well;

the sensored electronic valve assembly located along the tubular string, the sensored electronic valve assembly having:

a one way valve member operable to allow a flow of fluids within the tubular string in an uphole direction through the one way valve member and to prevent the flow of fluids within the tubular string in a downhole direction through the one way valve member;

a battery having a battery life of a predetermined time;

a sensor operable to detect a valve open signal; and

a battery powered opening device operable to move the one way valve member to a valve open position after receipt of the valve open signal by the sensor within the predetermined time only, the battery powered opening device being inoperable after the predetermined time; where

the one way valve member is operable to function as a one way valve after the predetermined time, allowing the flow of fluids in the uphole direction through the one way valve member when the battery powered opening device is inoperable, so that the one way valve member is a fluid flow path through the tubular string for produced fluids from the subterranean well.

9. The system of claim **8**, further including a command center, the command center operable to receive the valve open signal detected by the sensor and to deliver an engagement signal to the battery powered opening device.

10. The system of claim **8**, where the sensored electronic valve assembly further includes a valve body, the valve body housing the one way valve member and being secured in-line along the tubular string.

11. A method for controlling a flow of fluid within a subterranean well with a sensored electronic valve assembly, the method including:

extending a tubular string into the subterranean well as part of a completion system;

delivering the sensored electronic valve assembly into the subterranean well within the tubular string, the sensored electronic valve assembly having:

a one way valve member operable to allow a flow of fluids in an uphole direction through the one way valve member and to prevent the flow of fluids in a downhole direction through the one way valve member;

an electronic circuit including a battery and a command center, the battery having a battery life of a predetermined time;

a sensor; and

a battery powered opening device, the battery powered opening device being inoperable after the predetermined time; where

the one way valve member is operable to function as a one way valve after the predetermined time, allowing the flow of fluids in the uphole direction through the one way valve member when the battery powered opening device is inoperable so that the one way valve member is a fluid flow path through the tubular string for produced fluids from the subterranean well;

delivering a valve open signal into the subterranean well, the valve open signal being received by the sensor and being delivered to the command center by the sensor; and

delivering an engagement signal from the command center to the battery powered opening device, causing the opening device to move the one way valve member to a valve open position within the predetermined time only.

12. The method of claim **11**, further including removing the valve member from the subterranean well while the tubular string remains within the subterranean well.

13. The method of claim **11**, where the command center includes a data processor and a signal transmitter and the method further includes processing the valve open signal with the data processor and delivering the engagement signal from the command center to the battery powered opening device with the signal transmitter.

14. The method of claim **11**, where the battery powered opening device is a motor and the method further includes moving the one way valve member to the valve open position and retaining the one way valve member in the valve open position with the motor.

15. The method of claim **11**, where the battery powered opening device is an electromagnet and the method further includes moving the one way valve member to the valve open position and retaining the one way valve member in the valve open position with the electromagnet.

16. The method of claim **11**, where delivering the valve open signal into the subterranean well includes moving an intervention tool proximate to the sensored electronic valve assembly.

17. The method of claim **11**, where the one way valve member is a normal closed valve and the method further includes detecting a valve close signal with the sensor and delivering the valve close signal to the command center, and where the battery powered opening device is operable to disengage the one way valve member to allow the one way valve member to return to a normal closed position upon receipt of a disengagement signal from the command center.

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