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Annular closing system and method for use in blowout preventer

Abstract

A technique facilitates reliable operation of a blowout preventer (BOP) system in a wide range of challenging environments. To enable dependable and rapid closing of the internal passageway of the BOP system, an electronically actuated annular closing system is employed. The annular closing system may include, for example, a packer combined with a shift mechanism actuatable to compress the packer inwardly so as to seal off the internal passageway. An electronic actuator is coupled with the shift mechanism to enable selective actuation of the shift mechanism to achieve the sealed closing of the internal passageway.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
1839394	12/1931	Inge	N/A	N/A
2855172	12/1957	Jones	N/A	N/A
3321217	12/1966	Ahlstone	N/A	N/A
4095805	12/1977	Allen	N/A	N/A
4372026	12/1982	Mosing	N/A	N/A
4458876	12/1983	Schaeper	N/A	N/A
4715456	12/1986	Poe, Jr.	N/A	N/A
6998724	12/2005	Johansen et al.	N/A	N/A
7156183	12/2006	Williams	N/A	N/A
7159662	12/2006	Johansen et al.	N/A	N/A
7395855	12/2007	Ayling	N/A	N/A
7779918	12/2009	Cowie	N/A	N/A
7798466	12/2009	Springett et al.	N/A	N/A
8316872	12/2011	Milanovich	N/A	N/A
8381819	12/2012	Fern et al.	N/A	N/A
8621958	12/2013	Biester	N/A	N/A
8657011	12/2013	Vyas et al.	N/A	N/A
8776892	12/2013	Fern et al.	N/A	N/A
9019118	12/2014	Milne et al.	N/A	N/A
9388657	12/2015	Nelson	N/A	N/A
9388888	12/2015	Eriksen	N/A	N/A
9494007	12/2015	Bourgeau et al.	N/A	N/A
9581266	12/2016	Eriksen	N/A	N/A
9627940	12/2016	Eriksen	N/A	N/A
9631455	12/2016	Geiger et al.	N/A	N/A
9797216	12/2016	Rosa et al.	N/A	N/A
9822600	12/2016	Bourgeau et al.	N/A	N/A
10287841	12/2018	Zonoz et al.	N/A	N/A
10301897	12/2018	Arteaga et al.	N/A	N/A
10316605	12/2018	Bourgeau et al.	N/A	N/A
10329865	12/2018	Baugh	N/A	N/A
10370914	12/2018	Angstmann et al.	N/A	N/A
10415339	12/2018	Garro et al.	N/A	N/A
10465466	12/2018	Angstmann et al.	N/A	N/A
10487587	12/2018	Cummins	N/A	N/A
10570689	12/2019	Jaffrey	N/A	N/A
10597966	12/2019	Jones et al.	N/A	N/A
10648268	12/2019	Jaffrey et al.	N/A	N/A
10689933	12/2019	Deul et al.	N/A	N/A

10724324	12/2019	Boulanger	N/A	N/A
10801292	12/2019	Biester et al.	N/A	N/A
10900347	12/2020	Amsellem et al.	N/A	N/A
11060372	12/2020	Bourgeau et al.	N/A	N/A
11066892	12/2020	Gallagher et al.	N/A	N/A
11098551	12/2020	Angstmann et al.	N/A	N/A
11136853	12/2020	Zonoz et al.	N/A	N/A
11156054	12/2020	Alsup et al.	N/A	N/A
11339624	12/2021	Angstmann et al.	N/A	N/A
2004/0056229	12/2003	Biester	N/A	N/A
2010/0006298	12/2009	Voss	N/A	N/A
2013/0175045	12/2012	Rytlewski	N/A	N/A
2013/0199801	12/2012	Johnson	N/A	N/A
2013/0199802	12/2012	Weir	N/A	N/A
2013/0220637	12/2012	Fabela	166/382	E21B 31/18
2014/0354096	12/2013	Eriksen	N/A	N/A
2015/0152705	12/2014	Andrew et al.	N/A	N/A
2016/0290526	12/2015	Easter et al.	N/A	N/A
2017/0058623	12/2016	Jaffrey	N/A	N/A
2017/0130562	12/2016	Andrew et al.	N/A	N/A
2017/0218717	12/2016	Brinsden	N/A	N/A
2019/0145217	12/2018	Alsup et al.	N/A	N/A
2019/0338614	12/2018	Angstmann et al.	N/A	N/A
2020/0115987	12/2019	Rome	N/A	N/A
2021/0180427	12/2020	Zonoz	N/A	N/A
2021/0189826	12/2020	Gallagher et al.	N/A	N/A
2021/0340833	12/2020	Angstmann et al.	N/A	N/A
2021/0372224	12/2020	Tyler	N/A	N/A
2022/0136356	12/2021	Poveda et al.	N/A	N/A
2022/0389784	12/2021	Katanguri et al.	N/A	N/A

FOREIGN PATENT DOCUMENTS

Patent No.	**Application Date**	**Country**	**CPC**
2864579	12/2014	EP	N/A
3039226	12/2015	EP	N/A
3099934	12/2015	EP	N/A
3822514	12/2020	EP	N/A
2517959	12/2014	GB	N/A
343133	12/2017	NO	N/A
2017042152	12/2016	WO	N/A

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Background/Summary

BACKGROUND

(1) In many oil and gas well applications, various types of equipment may be used to contain and isolate pressure in the wellbore. For example, a blowout preventer system may be installed on a

wellhead to protect against blowouts. The blowout preventer has a longitudinal interior passage which allows passage of pipe, e.g. drill pipe, and other well components. Additionally, the blowout preventer has a variety of features including rams, e.g. pipe rams and shear rams, which facilitate rapid well sealing operations. Control over operation of the blowout preventer generally is achieved with various types of hydraulic controls. However, as deeper subsea wells and other types of deep wells are developed, the blowout preventer systems are required to operate in more challenging environments while at the same time improving operational availability. These challenging environments and increased requirements can render the hydraulic operating system susceptible to failure.

SUMMARY

(2) In general, a system and method facilitate reliable operation of a blowout preventer (BOP) system in a wide range of challenging environments. To enable dependable and rapid closing of the internal passageway of the BOP system, an electronically actuated annular closing system is employed. The annular closing system may comprise, for example, a packer combined with a shift mechanism actuatable to compress the packer inwardly so as to seal off the internal passageway. An electronic actuator is coupled with the shift mechanism to enable selective actuation of the shift mechanism to achieve the sealed closing of the internal passageway.

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

Description

BRIEF DESCRIPTION OF THE DRAWINGS

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

(2) FIG. **1** is an illustration of an example of an annular closing system implemented in an overall well BOP system mounted on a wellhead above a borehole, according to an embodiment of the disclosure;

(3) FIG. **2** is a schematic illustration of an example of an annular closing system, according to an embodiment of the disclosure;

(4) FIG. **3** is a schematic illustration of another example of an annular closing system, according to an embodiment of the disclosure;

(5) FIG. **4** is a schematic illustration of another example of an annular closing system, according to an embodiment of the disclosure;

(6) FIG. **5** is another schematic view of the annular closing system illustrated in FIG. **4**, according to an embodiment of the disclosure;

(7) FIG. **6** is an orthogonal view of an example of an annular closing system, according to an embodiment of the disclosure;

(8) FIG. **7** is a partially broken away view of the annular closing system illustrated in FIG. **6** in an open position, according to an embodiment of the disclosure;

(9) FIG. **8** is a partially broken away view of the annular closing system illustrated in FIG. **6** in a closed position, according to an embodiment of the disclosure;

(10) FIG. **9** is a cross-sectional view of the annular closing system, according to an embodiment of the disclosure;

(11) FIG. **10** is another cross-sectional view of the annular closing system, according to an embodiment of the disclosure;

(12) FIG. **11** is another partially broken away view of the annular closing system illustrated in FIG. **6** in an open position, according to an embodiment of the disclosure; and
(13) FIG. **12** is another partially broken away view of the annular closing system illustrated in FIG. **6** in a closed position, according to an embodiment of the disclosure.

DETAILED DESCRIPTION

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

(15) The disclosure herein generally involves a system and method which facilitate reliable operation of a blowout preventer (BOP) system in a wide range of challenging environments. For example, the BOP system may be employed in various challenging surface environments and in deep subsea environments where the BOP system is used to seal, control, and monitor a hydrocarbon well. Reliable operation in these types of environments is enhanced by constructing the BOP system as an electrically actuated system.

(16) For example, to enable dependable and rapid closing of an internal passageway of the BOP system, an electronically actuated annular closing system is employed. The annular closing system may comprise, for example, a packer combined with a shift mechanism actuatable to compress the packer inwardly so as to seal off the internal passageway. An electronic actuator is coupled with the shift mechanism to enable selective actuation of the shift mechanism to achieve the sealed closing of the internal passageway.

(17) In a specific embodiment, the annular closing system is in the form of an electric annular system that works by having a rotational plate activated by at least one externally mounted electronic actuator, e.g. an externally mounted electric bonnet assembly, which rotates the rotational plate. According to some applications, the rotational plate may be rotated about a wellbore axis. The rotational movement causes a plurality of inserts to translate and rotate inwardly against a packer. In some embodiments, the inserts may rotate inwardly against a donut surrounding the packer. The movement of the inserts squeezes the donut radially inward toward the packer which, in turn, collapses the packer inwardly against an internal pipe or to the borehole centerline. This packer movement in response to squeezing of the donut seals off the borehole. It should be noted various other types of mechanisms, components, and internal configurations may be utilized in enabling the electrically powered actuation.

(18) Referring generally to FIG. **1**, a well system **30** is illustrated as comprising a BOP system **32** for providing pressure control at a well **34**. In this example, the BOP system **32** is mounted on a wellhead **36**, e.g. a land-based wellhead or a subsea wellhead, located above a borehole **38**, e.g. a wellbore. The BOP system **32** may be arranged as a BOP stack **40** and may comprise a variety of BOP components, such as ram BOPs **42** and an annular closing system **44**. By way of example, the ram BOPs **42** may comprise pipe rams and shear rams. Additionally, the annular closing system **44** may be mounted above the ram BOPs **42**. As described below, the BOP system **32** may have a central, longitudinal passage for receiving tubular components **45**, e.g. drill pipe or other pipe, therethrough. The annular closing system **44** is in the form of an electronically actuated annular closing system.

(19) Referring generally to FIG. **2**, one example of an electronic annular closing system **44** is illustrated schematically as being actuatable via at least one electronic actuator **46**. In this particular embodiment, the annular closing system **44** comprises a plurality of electronic actuators **46**, e.g. two electronic actuators, mounted at one end of the annular closing system **44**.

(20) For example, each electronic actuator **46** may comprise an electric motor **48** connected to a shift mechanism **50** which may be shifted to cause closure of the BOP system central passageway. Electric motors **48** may comprise gears **52** or other actuation mechanisms which interact with the shift mechanism **50** to, for example, rotate the shift mechanism **50** when the gears **52** are rotated

via electric motors **48**.

(21) In another embodiment illustrated in FIG. **3**, at least one electronic actuator **46** is located on each end of the annular closing system **44**. In this example, the electronic actuators **46** may again comprise electric motors **48** (or other suitable electric actuators) coupled with corresponding shift mechanisms **50**. The motors **48** may be operated to rotate the shift mechanisms **50** so as to cause the desired sealing and closing of the BOP system central passageway at both ends of the annular closing system **44**.

(22) According to another embodiment, the electronic actuators **46** may be electronic linear actuators, as illustrated in FIGS. **4** and **5**. In this example, the electronic linear actuators **46** comprise motors **48** which drive a suitable rod, e.g. piston, linearly via a gearbox **54**. The electronic linear actuators **46** are oriented to cause the desired rotation of the shift mechanism or mechanisms **50** so as to close off the BOP system central passageway when needed/desired.

(23) Referring generally to FIG. **6**, a more detailed example of one embodiment of annular closing system **44** is illustrated. In this example, the annular closing system **44** is in a form of electronic annular closing system powered by electronic actuator **46**. A single electronic actuator **46** is illustrated, although additional electronic actuators **46** could be employed.

(24) In this embodiment, the annular closing system **44** comprises a body **56** which forms the outer structure or outer body supporting the components of annular closing system **44**. The electronic actuator **46** is mounted to body **56** via a suitable mounting structure **58**, such as a flange. By way of example, the electronic actuator **46** may be a linear electronic actuator having, for example, motor **48** coupled with gearbox assembly **54** which may comprise a roller screw and nut, a gear reducer, or various other mechanisms located within a rear housing for linearly driving a rod **60**, e.g. a piston. Although various types of electronic actuators **46** may be utilized, one example comprises motor **48** in which the motor output is rotational, e.g. the motor output is low torque-high rotational speed. In this example, the motor **48** is attached to gearbox assembly **54** and the gearbox transforms the low torque-high speed from the motor **48** into a high torque-low speed gearbox output. The gearbox then feeds into a roller screw (the gearbox also could feed into other screw configurations, such as a lead screw, ball screw, or other suitable screw type), and this roller screw then transfers that rotational energy/motion into the linear energy/motion of rod **60**. Some devices such as a roller screw make the transfer into linear energy/motion very efficiently, whereas other devices, e.g. a lead screw, may be less efficient but provide a simpler device.

(25) The rod **60** may be coupled with shift mechanism **50** via a coupling mechanism **62**. One example of coupling mechanism **62** comprises a clevis **64** which secures a pin **66** extending through a portion **68** of shift mechanism **50**.

(26) In this particular example, shift mechanism **50** is in the form of a shift plate **70**, and the shift plate portion **68** extends through a corresponding opening **72** formed generally radially through the outer body **56**. The movement of portion **68** via linear actuation of electronic actuator **46** causes the shift mechanism **50**/shift plate **70** to rotate about a BOP system central passageway **74**, a portion of which extends through the annular closing system **44**. Other components of annular closing system **44** may comprise a top **76** secured to body **56** via an actuator ring **78** or other suitable fastening mechanism.

(27) The top **76** cooperates with body **56** to secure a packer **80** therein-see packer **80** illustrated in FIGS. **7** and **8**. (In FIGS. **7** and **8**, the top **76** and actuator ring **78** have been removed to better illustrate packer **80**.) The shift mechanism **50**/plate **70** also may be secured in body **56** via top **76**. Packer **80** may have a variety of configurations, but one example utilizes a combination of an elastomeric sealing portion **82** and a metal portion, e.g. steel portion, formed by packer inserts **84** and/or other packer supporting structures. In some embodiments, the packer **80** may be surrounded by a donut **86** which may be formed of an elastomeric material or other suitable material which helps form a secure seal within the annular closing system **44**.

(28) As explained in greater detail below, actuation of the shift mechanism **50** via electronic

actuator **46** causes the shift mechanism **50** to rotate between an open position illustrated in FIG. **7** and a closed position illustrated in FIG. **8**. The rotation of shift mechanism **50** forces compression of the packer **80** inwardly so as to collapse the elastomeric sealing portion **82** of packer **80** against a tubular structure, e.g. a pipe **45**, extending through BOP system central passageway **74**. In many applications, the shift mechanism **50** and packer **80** are constructed for enabling sufficient inward compression so as to cause the packer **80** to seal on itself and to close off the central passageway **74** even if a tubular structure is not extending through the central passageway **74**.

(29) Referring generally to FIG. **9**, a cross-sectional illustration of annular closing system **44** is illustrated to better show some of the components as well as operation of those components. As illustrated, the annular closing system **44** comprises a plurality of inserts **88** which are shiftable to compress the packer **80** inwardly. By way of example, the inserts **88** may be positioned circumferentially around the packer **80**, e.g. around the donut **86**. The inserts **88** are coupled with shift mechanism **50** such that rotational movement of shift mechanism **50** forces radially inward movement of inserts **88** so as to compress donut **86** and to thus compress packer **80** in a radially inward direction.

(30) With additional reference to FIG. **10**, the inserts **88** may be coupled with shift mechanism **50** by a variety of coupling techniques. In the illustrated example, shift mechanism **50** is in the form of shift plate **70**, and the coupling technique utilizes a plurality of pins **90** and cooperating slots **92**. For example, the inserts **88** may comprise pins **90** oriented to extend into corresponding slots **92** formed in shift plate **70**. The pins **90** are restricted within slots **92** such that when the shift plate **70** is rotated via electronic actuator **46**, the walls of slots **92** effectively force movement of the pins **90** (and thus of the inserts **88**) in a generally radially inward direction. In some embodiments, the slots **92** also may be formed in body **56** so as to provide greater stability during the shifting action.

(31) It should be noted the annular closing system **44** may comprise various other components and features to achieve the desired actuation. The example illustrated in FIGS. **9** and **10** includes a split lock ring **94** position to secure the actuator ring **78** with respect to body **56**. Additionally, various lock segments **96**, seals, and other components/features may be utilized to secure and seal the various components of annular closing system **44**.

(32) As further illustrated in FIGS. **11** and **12**, the inserts **88** may be arranged circumferentially around packer **80** and in a slidable relationship with respect to each other. For example, the inserts **88** may be arranged in an “iris” formation. (In FIGS. **11** and **12**, the top **76**, actuator ring **78**, packer **80**, and donut **86** have been removed to better illustrate inserts **88** arranged within body **56**.) The iris formation enables the inserts **88** to slide against each other and in a radially inward direction as the shift plate **70** is rotated within body **56** to force actuation of inserts **88**.

(33) Effectively, the orientation of the slots **92** containing pins **90** forces the pins **90**, and thus the inserts **88**, to slide against each other so as to translate and rotate in the radially inward direction. As a result, the inserts **88** are forced from an open position illustrated in FIG. **11** to a closed position illustrated in FIG. **12**. This motion, in turn, is used to force the packer **80** to compress in the radially inward direction so as to form the desired seal along the BOP system central passageway **74**.

(34) Depending on the specific well operation, well environment, and well equipment, the overall well system **30** may be adjusted and various configurations may be employed. For example, the BOP system **32** may comprise many types of alternate and/or additional components. Additionally, the BOP system **32** may be combined with many other types of wellheads and other well components used in subsea hydrocarbon production operations or other types of operations.

(35) Furthermore, the components and arrangement of annular closing system **44** may vary according to the parameters of a given environment and/or well operation. For example, the electric actuation may be achieved by single electronic actuators **46** or by a plurality of cooperating electronic actuators **46**. Electronic actuators **46** may comprise motors **48** or other electrically powered mechanisms to provide the desired actuation motion. The shift mechanism **50** may be a

single mechanism or a plurality of mechanisms acting against a single packer **80** or a plurality of packers **80**. The electrically actuated, radially inward compression of the packer(s) **80** may be achieved by various arrangements of inserts **88** or by other types of lever mechanisms, expansion mechanisms, or other suitable mechanisms able to achieve sufficient compression of packer(s) **80** so as to close off the central passageway **74**. Similarly, the size, arrangement, materials, and interaction of the various components of annular closing system **44** may be adjusted according to the parameters of a given operation.

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

Claims

1. A system for preventing blowouts at a well, comprising: a blowout preventer (BOP) system having an annular closing system mounted on a plurality of ram BOPs, the annular closing system comprising: a packer configured to be compressed inwardly to seal off flow along an interior passage of the BOP system; a rotatable shift mechanism configured to selectively cause the packer to compress inwardly upon sufficient rotation of the rotatable shift mechanism; a plurality of slidable inserts positioned between the packer and the rotatable shift mechanism and shiftable by the rotatable shift mechanism to compress the packer inwardly; a donut positioned between the packer and the plurality of slidable inserts and configured to facilitate uniform compression of the packer by compression of the donut via shifting of the plurality of slidable inserts; and an electronic actuator coupled to the rotatable shift mechanism and configured to enable selective rotation of the rotatable shift mechanism.
2. The system as recited in claim 1, wherein the packer comprises an elastomeric sealing portion.
3. The system as recited in claim 2, wherein the packer is mounted in a body of the annular closing system.
4. The system as recited in claim 3, wherein the plurality of slidable inserts are arranged around the circumference of the packer.
5. The system as recited in claim 3, wherein the rotatable shift mechanism includes a shift plate, and wherein the shift plate is coupled to the plurality of slidable inserts via pins and slots arranged to receive the pins.
6. The system as recited in claim 5, wherein the pins extend from the plurality of slidable inserts and the slots are formed in both the shift plate and the body.
7. The system as recited in claim 3, wherein the rotatable shift mechanism includes a shift plate, and wherein the packer and the shift plate are secured in the body by a top mounted to the body via an actuator ring.
8. The system as recited in claim 1, wherein the BOP system is mounted on a wellhead.
9. The system as recited in claim 1, wherein the electronic actuator is an electronic linear actuator.
10. The system as recited in claim 9, wherein the electronic linear actuator comprises a motor driving a gearbox to move a rod linearly.
11. A method, comprising: constructing a BOP system with an annular closing system mounted on a plurality of ram BOPs; providing the annular closing system with a packer able to compress inwardly to seal off flow along an interior passage of the BOP system; employing a rotatable shift mechanism to selectively cause the packer to compress inwardly upon sufficient rotation of the rotatable shift mechanism; positioning a plurality of slidable inserts between the packer and the rotatable shift mechanism, and positioning a donut between the packer and the plurality of slidable inserts to facilitate uniform compression of the packer by compression of the donut; and coupling at least one electronic actuator to the rotatable shift mechanism to power selective rotation of the

rotatable shift mechanism.

12. The method as recited in claim 11, further comprising forming the packer with an elastomeric element combined with a plurality of metal packer inserts.