[0004] A closing flapper or other closing mechanism can exert force on the flow tube, which may result in damage to the flapper assembly, a pressure spike in a control line for the hydraulic fluid, and other undesirable results. For example, as the flapper is close to closing, the pressure differential across the flapper can force the flow tube toward the surface with a large amount of force. The large amount of force may break the flapper or seat hinge, shear a hinge pin, warp the flow tube, and impart momentum into the flow tube. In some situations, 1250 pound force (lbf) is transferred to the flow tube for every 100 psi of pressure differential across the flapper.

[0005] Safety valves are desirable that can handle forces from flappers or other closing mechanisms during closing.

Summary

[0006] Certain aspects and features of the present invention are directed to a safety valve that can include a flow tube that is allowed to move at least partially independent, or free, from a piston assembly to avoid negative effects from forces on the flow tube from a closing assembly.

[0007] According to a first~~One~~ aspect of the invention,~~relates to~~ a safety valve configured for being~~that can be~~ disposed in a wellbore through a fluid-producing formation is described,~~.~~ ~~T~~the safety valve comprising:~~includes~~ a piston assembly controllable from a surface of the wellbore; a flow tube; a closing assembly for allowing and preventing fluid

flow through , and a connecting assembly. The piston assembly can be controlled from a surface of the wellbore. The closing assembly can allow and prevent fluid flow through

an end of the flow tube;~~.~~ and ~~The~~ a connecting assembly ~~can be~~ positioned between the flow tube and the piston assembly,~~.~~ ~~t~~The connecting assembly being configured to ~~can~~ allow the flow tube to move toward the surface of the wellbore in response to a closing force exerted on the flow tube by the closing assembly and at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly; wherein the connecting assembly comprises a ring that is removably coupled to the flow tube, the ring comprising a first longitudinal end having a first diameter and a second longitudinal end having a second diameter larger than the first diameter, the second longitudinal end defining a boundary of a chamber configured to receive part of the flow tube as the flow tube moves toward the surface of the wellbore in response to the closing force.

[0008] According to a second aspect of the invention, a ~~nother aspect relates to a~~ connecting assembly for a safety valve ~~that can be~~configured for being disposed in a wellbore through a fluid-producing formation is described,~~.~~ ~~t~~The connecting assembly comprising:~~includes~~ a first end for~~, a second end, and a receiving member. The first end can~~ couplinge to a piston assembly and comprising a first diameter;~~.~~ a~~The~~ second end for~~can~~ engaginge a power spring that supports the flow tube and comprising a second diameter larger than the first diameter, the second end defining a boundary of a chamber configured to receive part of the flow tube;~~.~~ and a ~~The~~ receiving member configured to~~can~~ allow the flow tube to move toward the surface of the wellbore and into the chamber in

response to a closing force exerted on the flow tube by a flapper and at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly.

[0009] According to a third aspect of the invention, ~~nother aspect relates to~~ a safety valve configured for being~~that can be~~ disposed in a wellbore through a fluid-producing formation is described. ~~T~~the safety valve comprising:~~includes~~ a piston rod~~, a flow tube, a normally-closed flapper, and a ring assembly. The piston rod can be~~ controlled by (i) a piston and (ii)~~by~~ hydraulic fluid introduced into the wellbore from the surface; a flow tube; a ~~The~~ normally-closed flapper ~~can be~~ positioned proximate to an end of the flow tube for allowing and preventing fluid flow through the end of the flow tube; and a~~The~~ ring assembly ~~can be~~ positioned between the flow tube and the piston assembly and removably coupled to an exterior~~external to~~ part of the flow tube. ~~T~~the ring assembly ~~can~~

configured to allow the flow tube to move toward the surface of the wellbore in response to a closing force exerted on the flow tube by the normally-closed flapper and at least partially independent of movement toward the surface of the wellbore by the piston rod, wherein the ring assembly comprises a first longitudinal end having a first diameter and a second longitudinal end having a second diameter larger than the first diameter, the second longitudinal end defining a boundary of a chamber configured to receive part of the flow tube as the flow tube moves toward the surface of the wellbore in response to the closing force.

[0010] These illustrative aspects are mentioned not to limit or define the invention, but to provide examples to aid understanding of the inventive concepts disclosed. Other aspects, advantages, and features of the present invention will become apparent after review of the entire disclosure, figures, and claims.

Brief Description of the Drawings

[0011] Fig. 1 is a schematic illustration of a well system having a safety valve according to one aspect of the present invention.

[0012] Fig. 2 is a cross-sectional side view of the safety valve of Fig. 1 according to one aspect of the present invention.

[0013] Fig. 3 is a cross-sectional side view of part of the safety valve including a closing assembly of Fig. 1 according to one aspect of the present invention.

[0014] Fig. 4 is a cross-sectional side view of part of the safety valve of Fig. 1 including a connecting assembly according to one aspect of the present invention.

[0015] Fig. 5 is a perspective view of a ring that is part of a connecting assembly of the safety valve of Fig. 1 according to one aspect of the present invention.

Claims

1. A safety valve configured for being disposed in a wellbore through a fluid-producing formation, the safety valve comprising:

a piston assembly controllable from a surface of the wellbore;

a flow tube;

a closing assembly for allowing and preventing fluid flow through an end of the flow tube; and

a connecting assembly positioned between the flow tube and the piston assembly, the connecting assembly being configured to allow the flow tube to move toward the surface of the wellbore in response to a closing force exerted on the flow tube by the closing assembly and at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly;

wherein the connecting assembly comprises a ring that is removably coupled to the flow tube, the ring comprising a first longitudinal end having a first diameter and a second longitudinal end having a second diameter larger than the first diameter, the second longitudinal end defining a boundary of a chamber configured to receive part of the flow tube as the flow tube moves toward the surface of the wellbore in response to the closing force.

2. The safety valve of claim 1, wherein the connecting assembly is configured to allow the flow tube to move toward the surface of the

wellbore at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly by allowing the flow tube to move more than a corresponding amount by which a piston rod of the piston assembly moves toward the surface.

3. The safety valve of claim 1, further comprising:

a power spring disposed external to the flow tube and configured for biasing the flow tube normally towards the surface of the wellbore,

wherein the piston assembly comprises:

a port for receiving hydraulic fluid from a control line;

a piston controllable by the hydraulic fluid introduced into the wellbore from the surface; and

a piston rod controllable by the piston,

wherein the ~~connecting assembly comprises:~~

~~a~~ a ring is positioned external to the flow tube, ~~and defining a chamber configured to receive part of the flow tube, the ring being~~ coupled to the piston rod, and configured to engage the power spring; ~~and~~

wherein the connecting assembly comprises a take-up spring disposed in the chamber, the take-up spring being biased normally away from the surface of the wellbore~~,~~; and

wherein the closing assembly comprises a normally-closed flapper positioned proximate to an end of the flow tube, the normally-closed flapper being configured to apply the closing force to the flow tube.

4. The safety valve of claim 3, wherein the ring is coupled to the piston rod by coupling mechanisms, the safety valve further comprising gaps between the coupling mechanisms and the ring, wherein the gaps are configured to allow the piston rod to move at least partially independent to the ring.

5. The safety valve of claim 1, wherein the connecting assembly is configured to allow the flow tube to move toward the surface of the wellbore by one-half inches or more at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly.

6. The safety valve of claim 1, wherein the connecting assembly is configured to allow the flow tube to move toward the surface of the wellbore by an amount that is in a range of one inch to six inches at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly.

7. The safety valve of claim 1, wherein the connecting assembly comprises:

~~a ring external to the flow tube and defining a chamber configured to receive part of the flow tube; and~~

a take-up spring disposed in the chamber, the take-up spring being biased normally away from the surface of the wellbore and configured for being compressed by the flow tube in response to the closing force and in response to the flow tube moving at least partially independent to movement by the piston assembly.

8. The safety valve of claim 1, wherein: ~~the connecting assembly comprises:~~

~~a~~ the first longitudinal end ~~for coupling~~ is coupled to the piston assembly;

~~a~~ the second longitudinal end ~~for engaging~~is configured to engage a power spring that supports the flow tube; and

~~a receiving member~~ the ring is configured to allow the flow tube to move toward the surface of the wellbore in response to the closing force exerted on the flow tube by a flapper and at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly.

9. A connecting assembly for a safety valve configured for being disposed in a wellbore through a fluid-producing formation, the connecting assembly comprising:

a first end for coupling to a piston assembly and comprising a first diameter;

a second end for engaging a power spring that supports a flow tube and comprising a second diameter larger than the first diameter, the second end defining a boundary of a chamber configured to receive part of the flow tube; and

a receiving member configured to allow the flow tube to move toward the surface of the wellbore and into the chamber in response to a closing force exerted on the flow tube by a flapper and at least partially

independent of movement toward the surface of the wellbore by at least part of the piston assembly.

of the wellbore by an amount that is in a range of one inch to six inches at least partially independent of movement toward the surface of the wellbore by at least part of the piston assembly.

14. The connecting assembly of claim 9, wherein the first end comprises openings configured to receive part of the piston assembly,

wherein the second end comprises a raised boss.

15. A safety valve configured for being disposed in a wellbore through a fluid-producing formation, the safety valve comprising:

a piston rod controllable by (i) a piston and (ii) hydraulic fluid introduced into the wellbore from the surface;

a flow tube;

a normally-closed flapper positioned proximate to an end of the flow tube for allowing and preventing fluid flow through the end of the flow tube; and

a ring assembly positioned between the flow tube and the piston assembly and removably coupled to an exterior ~~external to~~ part of the flow tube, the ring assembly being configured to allow the flow tube to move toward the surface of the wellbore in response to a closing force exerted on the flow tube by the normally-closed flapper and at least partially independent of movement toward the surface of the wellbore by the piston rod.

wherein the ring assembly comprises a first longitudinal end having a first diameter and a second longitudinal end having a second diameter larger than the first diameter, the second longitudinal end defining a boundary of a chamber configured to receive part of the flow tube as the flow tube moves toward the surface of the wellbore in response to the closing force.

16. The safety valve of claim 15, wherein the ring assembly is configured to allow the flow tube to move toward the surface of the wellbore at least partially independent of movement toward the surface of the wellbore by the piston rod by allowing the flow tube to move more than a corresponding amount by which a piston rod of the piston assembly moves toward the surface.

17. The safety valve of claim 15, further comprising:

a power spring disposed external to the flow tube and configured for biasing the flow tube normally towards the surface of the wellbore,

a port for receiving hydraulic fluid from a control line; and

a piston controllable by the hydraulic fluid introduced into the wellbore from the surface, the piston rod being controllable by the piston,

wherein ~~the ring assembly comprises:~~

~~a ring external to the flow tube and defining a chamber configured to receive part of the flow tube,~~ the ring assembly being is coupled to the piston rod and configured to engage the power spring; ~~and~~

wherein a take-up spring is disposed in the chamber, the take-up spring being biased normally away from the surface of the wellbore~~,~~; and

wherein the ring assembly is coupled to the piston rod by coupling mechanisms, the safety valve further comprising gaps between the coupling mechanisms and the ring assembly, wherein the gaps are configured to allow the piston rod to move at least partially independent to the ring assembly.

18. The safety valve of claim 15, wherein the ring assembly is configured to allow the flow tube to move toward the surface of the wellbore by one-half inches or more at least partially independent of movement toward the surface of the wellbore by the piston rod.

19. The safety valve of claim 15, wherein the ring assembly is configured to allow the flow tube to move toward the surface of the wellbore by an amount that is in a range of one inch to six inches at least partially independent of movement toward the surface of the wellbore by the piston rod.

20. The safety valve of claim 15, wherein the ring assembly comprises:

~~a ring external to the flow tube and defining a chamber configured to receive part of the flow tube; and~~

a take-up spring disposed in the chamber, the take-up spring being biased normally away from the surface of the wellbore and configured for being compressed by the flow tube in response to the closing force and in response to the flow tube moving at least partially independent to movement by the piston rod.