

WELLHEAD ANNULUS SEAL HAVING A WICKERED SURFACE

BACKGROUND

1. Field of Invention

[0001] The present disclosure relates in general to a wellhead assembly having a seal between coaxial members, where wickers are formed on a surface of the seal.

2. Description of Prior Art

[0002] Seals are typically inserted between inner and outer wellhead tubular members to contain internal well pressure. The inner wellhead member is generally a hanger for supporting either casing or tubing that extends into the well. Outer wellhead members are usually one of a wellhead housing, or can be a casing hanger when the inner member is a tubing hanger. A variety of seals located between the inner and outer wellhead members are known. Examples of known seals are elastomeric, metal, and combinations thereof and elastomeric rings. The seals may be set by a running tool, or they may be set in response to the weight of the string of casing or tubing. One type of metal-to-metal seal has seal body with inner and outer walls separated by a cylindrical slot, forming a "U" shape. An energizing ring is pushed into the slot in the seal to deform the inner and outer walls apart into sealing engagement with the inner and outer wellhead members, which may have wickers formed thereon. The energizing ring is typically a solid member with a lower end having a wedge-shaped cross section. The deformation of the seal's inner and outer walls exceeds the yield strength of the material of the seal ring, making the deformation permanent.

[0003] Thermal growth between the casing or tubing and the wellhead may occur. The well fluid flowing upward through the tubing, and annulus fluids, heats the string of tubing, and to a lesser degree the surrounding casing. The temperature increase may cause the tubing hanger and/or casing hanger to move axially a slight amount relative to the outer wellhead member. During the heat up transient, annulus pressure may build up as the fluids comprising the volume below the seal try to expand. This annulus pressure build-up and thermal expansion of the casing and/or tubing string combine to exert a large upward axial force, often referred to as a "lockdown force", against the annulus seal. If this force exceeds the retention capacity of the seal, the pressure controlling barrier between the inner and outer wellhead tubular members can

be compromised. Seal leakage can also occur due to a collection of debris on the wickers that interferes with energizing the seal and introduces a leak path across the wickers.

[0004] A large axial load between the seal and its mating surfaces due to thermal transients may also cause the seal to leak. One approach to preventing this type of movement is through the use of lockdown C-rings on the seal. The C-rings engage the outer tubular member and/or the hanger when the seal is set, locking the seal to the hanger, as well as the hanger to the wellhead. Another approach has been to use the sealing element itself as a locking mechanism. In these approaches, lockdown as well as sealing is thus provided by the seal. Further, a lockdown style hanger may be utilized to lock the casing hanger in place. This requires an extra trip to install the lockdown style hanger.

SUMMARY OF THE INVENTION

[0005] Disclosed herein is an example of a seal assembly for use in a wellhead assembly which includes an annular seal body which is made up of an elongate inner leg, an elongate outer leg set radially outward from the inner leg, and an elongate slot defined between the inner and outer legs. Wickers are provided on a curved surface of the seal body and selectively engage a tubular surface within the wellhead assembly. The wickers can be on the inner leg, the outer leg, or on both legs. Optionally, the tubular can be a casing hanger, tubing hanger, or wellhead housing. The seal assembly can further include a protective foam layer adhered to the wickers.

[0006] Also disclosed herein is a wellhead assembly which includes inner and outer wellhead tubulars, an annulus between the inner and outer tubulars, and an annular seal in the annulus. In this example the annular seal is made up of an inner leg that is in selective sealing contact with the inner tubular, an outer leg that is in selective sealing contact with the outer tubular, a space between the inner and outer legs, and wickers on a circumference of a curved surface of the seal. In an example, the wickers are on an inner surface of the inner leg and project into an outer surface of the inner tubular. Optionally, the wickers can be on an outer surface of the outer leg and project into an inner surface of the outer tubular. In another example, wickers are on an inner surface of the inner leg and are on an outer surface of the outer leg. An inlay may be set in one of the inner and outer tubulars and strategically located for engagement with the wickers when the legs are in sealing contact with the tubulars. In one example the seal includes nickel alloy.

[0007] A method of sealing an annulus between an inner and outer tubular in a wellhead assembly is disclosed herein. In one example the method includes providing a seal assembly with an annular seal body with inner and outer legs, and with wickers that circumscribe a curved surface on the body, inserting the seal assembly into the annulus, and urging the inner and outer legs radially apart and into respective sealing engagement with an outer surface of the inner tubular and an inner surface of the outer tubular. The wickers can be on an outer surface of the outer leg and embed into the inner surface of the outer tubular during the step of urging the legs apart. In an alternative, the wickers can be on an inner surface of the inner leg and embed into the outer surface of the inner tubular when the legs are urged apart. The method can further involve removing the seal assembly from the wellhead assembly, applying a protective layer onto the wickers, and repeating the steps of inserting and urging apart.

BRIEF DESCRIPTION OF DRAWINGS

[0008] Some of the features and benefits of the present invention having been stated, others will become apparent as the description proceeds when taken in conjunction with the accompanying drawings, in which:

[0009] FIG. 1 is a side sectional view of an example of a seal assembly in accordance with the present invention.

[0010] FIG. 1A is a side sectional and enlarged view of a portion of the seal assembly of FIG. 1.

[0011] FIG. 2 is a side sectional view of an alternate embodiment of the seal assembly of Figure 1 and in accordance with the present invention.

[0012] FIG. 3 is a side sectional view of the seal assembly of Figure 1 installed in a wellhead assembly.

[0013] While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to that embodiment. On the contrary, it is intended to cover all alternatives, modifications, and equivalents, as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF INVENTION

[0014] The method and system of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings in which embodiments are shown. The method and system of the present disclosure may be in many different forms and should not be construed as limited to the illustrated embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey its scope to those skilled in the art. Like numbers refer to like elements throughout.

[0015] It is to be further understood that the scope of the present disclosure is not limited to the exact details of construction, operation, exact materials, or embodiments shown and described, as modifications and equivalents will be apparent to one skilled in the art. In the drawings and specification, there have been disclosed illustrative embodiments and, although specific terms are employed, they are used in a generic and descriptive sense only and not for the purpose of limitation.

[0016] Shown in Figure 1 in side sectional view is an example embodiment of a wellhead assembly 10 in which a production casing hanger 12 is shown landed onto an intermediate casing hanger 14. A downward facing shoulder 15 on production casing hanger 12 contacts an upward facing shoulder 16 on an upper terminal surface of casing hanger 14. An annular wellhead housing 18 circumscribes both the production hanger 12 and intermediate hanger 14. An annulus 20 extends axially between the intermediate hanger 12, and wellhead housing 18. In the example of Figure 1, an upper end of annulus 20 is defined by the sealing interfaces created between the outer seal leg 30 and wellhead housing 18 as well as the inner seal leg 28 and intermediate hanger 14.

[0017] Inserted within annulus 20 is a seal assembly 22 shown urged into sealing contact with the respective outer and inner surfaces of intermediate casing hanger 14 and wellhead housing 18. An annular retaining ring 24 threadingly engages an upper end of the seal assembly 22 and annular energizing ring 26 is shown inserted within the seal assembly 22. Energizing Ring 26 urges inner leg 28 of the seal assembly 22 radially inward and against the intermediate casing hanger 14. Energizing ring 26 also urges outer leg 30 of seal assembly 22 radially outward against casing hanger 18. The seal assembly 22 is an annular member having a curved surface along its outer radius and inner radius. The legs 28, 30 are elongate members whose elongate sides extend in a direction substantially parallel with an axis A_X of the seal assembly 22. Outer leg 30, which is shown into sealing contact with an inner surface of wellhead housing 18, further

includes wickers 34 on its outer radial surface, and which extend an axial length on the outer radial surface.

[0018] When the seal assembly 22 is energized and outer leg 30 is urged radially outward, wickers 34 project radially outward and into the wellhead housing 18; a sealing surface is formed along the interface between the outer leg 30 and wellhead housing 18. The material of the seal assembly 22 is harder than material of the wellhead housing 18 so that the wickers 34 can penetrate and plastically deform the wellhead housing 18. An optional inlay 36 may be strategically located on the inner circumference of the wellhead housing, so the wickers 34 engage the inlay 36 when seal assembly 22 is energized. In this example, inlay 36 can be formed from a metal softer than wellhead housing 18 and the metal making up seal assembly 22. Example materials for the seal assembly include nickel-based alloys, such as Inconel® 718. In addition to providing a sealing interface between the seal assembly 22 and wellhead housing 18, engaging wickers 34 with wellhead housing 18 can also create a coupling which opposes axial respective movement between seal assembly 22 and wellhead housing that may be introduced by thermal expansion and other similar occurrences.

[0019] Referring now to Figure 1A, an enlarged view of a portion of the wellhead assembly 10 is shown in side sectional view. In this example, wickers 34 are generally triangular elements with a tip 37 with sharp pointed ends. The sharp ends reduce the force required to embed the wickers 34 into wellhead housing 18 and plastically deform the material of the wellhead housing 18. Although the wickers 34 are shown as adjoining, spaces may be included between adjacent wickers 34, or optionally spaces may exist between adjacent groups of wickers 34. In one example, the distance between adjacent tips 37 is about 0.125 inches. Additionally, the material of what is being deformed by the wickers 34 (e.g. the casing 14, housing 18, or inlays 36, 40), can have a hardness that ranges from about 45% to about 55%, or more, of the hardness of the material of the seal assembly 22.

[0020] Referring back to Figure 1, inner leg 28 may also include wickers 38 that are shown engaging with an outer radial surface of casing hanger 16 and plastically deforming that portion to create a sealing interface between inner leg 28 and casing hanger 16. Optionally, an inlay 40 may be provided on the outer surface of casing hanger 16 and strategically located so that inlay 40 is engaged by wickers 38. Similar to inlay 36, inlay 40 may be formed from a material softer than the material used for forming production casing hanger 12 and/or inner leg 28. Optional embodiments exist, wherein no inlays are provided on either of the casing hanger 16 or wellhead

housing 18. Further optionally, wickers 34 may be provided on a single one of the legs 28, 30; in this example the other leg 28, 30 would be substantially smooth.

[0021] Figure 2 illustrates an alternate embodiment of the seal assembly 22A in an uninstalled configuration wherein the energizing ring 26 is set axially upward from its energizing position of Figure 1. In this example, an upward facing shoulder on the outer radial surface of the energizing ring 26 is in contact with a lower terminal end of the retaining ring 24. Further in the example of Figure 2, foam 42 is provided on the wickers 34 on the outer leg 30. Also in the example of Figure 2, the inner radial surface of inner leg 28 is substantially smooth and having no wickers 34 formed thereon as mentioned above. In this example, the foam 42 fills the space between adjacent wickers 34. In an example, the foam includes gas filled beads suspended in a matrix, such as a binding agent or resin. The beads (not shown) can be glass. By axially urging energizing ring 26 downward so that its lower nose enters space 32 between legs 28, 30, wickers 34 are urged radially outward. In an example, the resulting forces from energizing the seal assembly 22, 22A crushes the foam 42 and releases a volume of gas trapped inside the glass beads which reduces the hydraulic pressure that builds between the wicker tips 37 as the seal assembly 22, 22A is energized in a submerged environment into particles that do not interfere with formation of the sealing interface between wickers and the associated tubular in which the wickers are embedded. Advantages of the embodiments described herein are that the seal element 22 can be constructed from a much higher yield strength than the wellhead housing 18 or the casing hangers 12, 14, which in turn allows much greater lockdown capacities to be achieved. While at surface, the seal assembly 22, 22A can either be replaced or repaired, and a fresh amount of foam 42 reapplied before inserting the replacement or repaired seal assembly 22, 22A back into the wellhead assembly 10. Current known embodiments of seal assemblies with wickers are provided on tubulars, which are usually not pulled when replacing a seal, and as such wickers will no longer benefit from the original volume of foam during a reinstallation of a seal assembly because the foam is crushed and consumed during an initial seal assembly installation.

[0022] The wellhead assembly 10 is shown in Figure 3 and which includes a production tree 44 mounted on wellhead housing 18. In this example embodiment, production casing hanger 12 and intermediate casing hanger 14 are circumscribed by wellhead housing 18 and seal assembly 22 is shown set in the annulus between tubing and casing hangers 12, 14 and wellhead housing 18. Further shown in Figure 3 is the wellbore 46 over which wellhead assembly 10 is mounted. Depending into wellbore 46 is a casing string 48 whose upper end is attached to intermediate casing hanger 14, and which circumscribes a tubing string 50 which is supported on production

casing hanger 12. In the example of Figure 3, wellhead assembly 10 can be subsea or on surface and used for controlling fluids produced from within wellbore 46.

[0023] The present invention described herein, therefore, is well adapted to carry out the objects and attain the ends and advantages mentioned, as well as others inherent therein. While a presently preferred embodiment of the invention 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 invention disclosed herein and the scope of the appended claims.

CLAIMS

What is claimed is.

1. A seal assembly for use in a wellhead assembly comprising:

an annular seal body comprising,

an elongate inner leg,

an elongate outer leg set radially outward from the inner leg, and

an elongate slot defined between the inner and outer legs; and

wickers on a curved surface of the seal body that are selectively engaged with a tubular within the wellhead assembly.
2. The seal assembly of claim 1, wherein the wickers are on the inner leg.
3. The seal assembly of claim 1, wherein the wickers are on the outer leg.
4. The seal assembly of claim 1, wherein the wickers are on the inner and the outer leg.
5. The seal assembly of claim 1, wherein the tubular comprises a casing hanger.
6. The seal assembly of claim 1, wherein the tubular comprises a tubing hanger.
7. The seal assembly of claim 1, wherein the tubular comprises a wellhead housing.
8. The seal assembly of claim 1, further comprising a protective foam layer adhered to the wickers.
9. A wellhead assembly comprising:

inner and outer wellhead tubulars;

an annulus between the inner and outer tubulars;

an annular seal in the annulus comprising,

an inner leg that is in selective sealing contact with the inner tubular,

an outer leg that is in selective sealing contact with the outer tubular,
a space between the inner and outer legs, and
wickers on a circumference of a curved surface of the seal.

10. The wellhead assembly of claim 9, wherein the wickers are on an inner surface of the inner leg and project into an outer surface of the inner tubular.
11. The wellhead assembly of claim 9, wherein the wickers are on an outer surface of the outer leg and project into an inner surface of the outer tubular.
12. The wellhead assembly of claim 9, wherein wickers are on an inner surface of the inner leg and are on an outer surface of the outer leg.
13. The wellhead assembly of claim 9, further comprising an inlay in one of the inner and outer tubulars that is strategically located for engagement with the wickers when the legs are in sealing contact with the tubulars.
14. The wellhead assembly of claim 9, wherein the seal comprises nickel alloy.
15. A method of sealing an annulus between an inner and outer tubular in a wellhead assembly comprising:
 - (a) providing a seal assembly comprising an annular seal body with inner and outer legs, and with wickers that circumscribe a curved surface on the body;
 - (b) inserting the seal assembly into the annulus;
 - (c) urging the inner and outer legs radially apart and into respective sealing engagement with an outer surface of the inner tubular and an inner surface of the outer tubular.
16. The method of claim 15, wherein the wickers are on an outer surface of the outer leg and embed into the inner surface of the outer tubular during step (c).
17. The method of claim 15, wherein the wickers are on an inner surface of the inner leg and embed into the outer surface of the inner tubular during step (c).
18. The method of claim 15, further comprising, removing the seal assembly from the wellhead assembly, applying a protective layer onto the wickers, and repeating steps (b) and (c).