of a suitable friction reducer comprising acrylamide is a copolymer of acrylamide and acrylic acid. Such friction reducers may further comprise additional monomers, such as 2-acrylamido-2-methylpropanesulfonic acid, N,N-dimethyl acrylamide, vinylsulfonic acid, N-vinyl acetamide, N-vinyl formamide, and mixtures thereof.

[0028] Figure 2 shows a cross-section view of the seal ring backup device **100** oriented similarly (*i.e.*, pressure flows left to right) to the view shown in Figure 1A. The hatched area represents the cross-sectioned portion of the seal ring backup device **100**. In this embodiment, the top surface **118** (Figures 1B and IC) of the seal ring backup device **100** is flat or nearly flat. Once installed, the top surface **118** should make contact with the seal ring **300**.

[0029] In some embodiments, the top surface **118** may be angled, v-ringed or u-cupped, etc. to facilitate the contact between the top surface **118** and the seal ring **300** (Figure 3H). In the embodiment shown in Figure 3H, a seal ring backup device **100** has been installed on opposing sides of the seal ring **300**. Figure 3H also represents the bonding of the seal ring backup devices to the seal ring.

[0030] Referring again to the embodiment shown in Figure 2, the bottom surface is contoured as a wedge **202**. The bottom surface also has a chamfered cut **200**. In some embodiments, the bottom surface **120** may be flat (Figure 3A), convex (Figure 3B), concave (Figure 3C), angled (Figure 3D), stepped (Figure 3E), V-ring or U-cupped (Figure 3G), etc. These shapes allow the seal ring backup device **100** to conform to a variety of existing seal shapes.

[0031] Figures 4A and 4B show at least two embodiments of a sealing system. Referring to Figures 4A and 4B, the seal ring backup device **100** is generally configured to fit into a gland **404** and engage a seal ring **300**. Figure 4A shows an embodiment in which the gland **404** has been machined directly onto a piston rod **402**. Alternatively, Figure 4B shows an embodiment in which the gland **404** has been machined onto the bore **400**.

[0032] Figures 5A-5B show two separate cross-sectional views related to the embodiment shown in Figure 4A. Figure 5A shows the sealing system in a non-sealed state where there is no pressure difference inside the gland. Figure 5B

CLAIMS

1. A seal ring back-up device, comprising:

an annular body having a top surface, a bottom surface opposite the top surface, an inner surface, and an outer surface opposite the inner surface, wherein the inner surface exhibits an inner diameter of the annular body and the outer surface exhibits an outer diameter of the annular body; and

a scarf cut defined in the annular body and extending between the inner and outer surfaces at an angle relative to the top surface, wherein the annular body is arrangeable within a gland and the top surface is engageable with a seal ring,

wherein the top surface comprises a surface contour shape selected from the group consisting of convex, concave, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

2. The seal ring back-up device of claim 1, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface.

3. The seal ring back-up device of claim 1, wherein the bottom surface is wedge shaped.

4. The seal ring back-up device of claim 1, wherein the surface contour shape is concave to receive the seal ring.

5. The seal ring back-up device of claim 1, wherein the annular body comprises a material selected from the group consisting of a metal, a metal alloy, a plastic, an amorphous polymer, glass, clay, ceramic, a thermoset, an epoxy, silica, carbon black, carbon fibers, nanoclay, nanotubes, boron, and any combination thereof.

6. The seal ring back-up device of claim 1, wherein the annular body comprises a material selected from the group consisting of polyphenylene sulfide, polyaryletherketone, an amorphous polymer, a polyimide, a polyamide, a sulfone, any derivative thereof, and any combination thereof.

7. The seal ring back-up device of claim 1, further comprising a surface coating disposed on the annular body, the surface coating being selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.

8. A sealing system, comprising:

a bore;

a piston extendable within the bore and thereby defining an extrusion gap between the bore and the piston;

a gland defined in at least one of the bore and the piston and providing a wall;

a seal ring arranged within the gland; and

a seal ring back-up device arranged within the gland in direct contact with the seal ring and providing an annular body having a top surface engageable with the seal ring, a bottom surface opposite the top surface and engageable with the wall, an inner surface, and an outer surface opposite the inner surface,

wherein a scarf cut is defined through the annular body and extends between the inner and outer surfaces at an angle relative to the top surface.

9. The sealing system of claim 8, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, the opposing sloped faces being slidingly engageable with one another during operation.

10. The sealing system of claim 8, wherein the bottom surface and the wall are each wedge shaped.

11. The sealing system of claim 8, wherein the top surface comprises a surface contour shape selected from the group consisting of flat, convex, concave, angled, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

12. The sealing system of claim 8, wherein the annular body comprises a material selected from the group consisting of a metal, a metal alloy, a plastic, an amorphous polymer, glass, clay, ceramic, a thermoset, an epoxy, silica, carbon black, carbon fibers, nanoclay, nanotubes, boron, polyphenylene sulfide, polyaryletherketone, an amorphous polymer, a polyimide, a polyamide, a sulfone, any derivative thereof, and any combination thereof.

13. The sealing system of claim 8, further comprising a surface coating disposed on the annular body, the surface coating being selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.

14. The sealing system of claim 8, wherein the seal ring is bonded to the seal ring back-up device.

15. A method, comprising:

arranging a seal ring within a gland defined within one of a bore and a piston, the piston being extendable within the bore and thereby defining an extrusion gap between the bore and the piston;

arranging a seal ring back-up device within the gland and in direct contact with the seal ring, the seal ring back-up device providing an annular body having a top surface, a bottom surface opposite the top surface, an inner surface, and an outer surface opposite the inner surface, wherein a scarf cut is defined in the annular body and extends between the inner and outer surfaces at an angle relative to the top surface;

forcing the seal ring against the top surface as an external pressure increases and thereby forcing the bottom surface against a wall defined in the gland; and

closing the extrusion gap with the seal ring back-up device as the bottom surface is forced against the wall defined and thereby preventing the seal ring from deforming into the extrusion gap.

16. The method of claim 15, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, and wherein arranging the seal ring back-up device within the gland comprises:

separating the opposing sloped faces to increase an inner diameter of the seal ring back-up device; and

extending the piston through the seal ring back-up device until the seal ring back-up device locates the gland.

17. The method of claim 15, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, and wherein closing the extrusion gap with the seal ring back-up device comprises slidingly engaging the opposing sloped faces on one another.

18. The method system of claim 15, wherein the bottom surface and the wall are each wedge shaped and forcing the bottom surface against the wall comprises slidingly engaging the bottom surface against the wall.

19. The method of claim 15, wherein forcing the seal ring against the top surface comprises forcing the seal ring against a surface contour shape provided on the top surface, the surface contour shape being selected from the group consisting of flat, convex, concave, angled, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

20. The method of claim 15, wherein arranging the seal ring back-up device within the gland is preceded by coating the annular body with a surface coating selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.

of a suitable friction reducer comprising acrylamide is a copolymer of acrylamide and acrylic acid. Such friction reducers may further comprise additional monomers, such as 2-acrylamido-2-methylpropanesulfonic acid, N,N-dimethyl acrylamide, vinylsulfonic acid, N-vinyl acetamide, N-vinyl formamide, and mixtures thereof.

[0028] Figure 2 shows a cross-section view of the seal ring backup device **100** oriented similarly (*i.e.,* pressure flows left to right) to the view shown in Figure 1A. The hatched area represents the cross-sectioned portion of the seal ring backup device **100**. In this embodiment, the top surface **118** (Figures 1B and IC) of the seal ring backup device **100** is flat or nearly flat. Once installed, the top surface 118 should make contact with the seal ring **300**.

[0029] In some embodiments, the top surface **118** may be angled, v-ringed or u-cupped, etc. to facilitate the contact between the top surface **118** and the seal ring **300** (Figure 3H). In the embodiment shown in Figure 3H, a seal ring backup device **100** has been installed on opposing sides of the seal ring **300**. Figure 3H also represents the bonding of the seal ring backup devices to the seal ring.

[0030] Referring again to the embodiment shown in FIG. 2, the inner surface 114 is contoured as a wedge 202. The bottom surface 120 also has a chamfered cut 200. In some embodiments, the top surface 118 may be flat (FIG. 3A), convex (FIG. 3B), concave (FIG. 3C), angled (FIG. 3D), stepped (FIG. 3E), V-ring or U-cupped (FIG. 3G), etc. These shapes allow the seal ring backup device 100 to conform to a variety of existing seal shapes.

[0031] Figures 4A and 4B show at least two embodiments of a sealing system. Referring to Figures 4A and 4B, the seal ring backup device **100** is generally configured to fit into a gland **404** and engage a seal ring **300**. Figure 4A shows an embodiment in which the gland **404** has been machined directly onto a piston rod **402**. Alternatively, Figure 4B shows an embodiment in which the gland **404** has been machined onto the bore **400**.

[0032] Figures 5A-5B show two separate cross-sectional views related to the embodiment shown in Figure 4A. Figure 5A shows the sealing system in a non-sealed state where there is no pressure difference inside the gland. Figure 5B

CLAIMS

1. A seal ring back-up device, comprising:

an annular body having a top surface, a bottom surface opposite the top surface, an inner surface, and an outer surface opposite the inner surface, wherein the inner surface exhibits an inner diameter of the annular body and the outer surface exhibits an outer diameter of the annular body; and

a scarf cut defined in the annular body and extending between the inner and outer surfaces at an angle relative to the top surface, wherein the annular body is arrangeable within a gland and the top surface is engageable with a seal ring,

wherein the top surface comprises a surface contour shape selected from the group consisting of convex, concave, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

2. The seal ring back-up device of claim 1, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface.

3. The seal ring back-up device of claim 1, wherein the bottom surface is wedge shaped.

4. The seal ring back-up device of claim 1, wherein the surface contour shape is concave to receive the seal ring.

5. The seal ring back-up device of claim 1, wherein the annular body comprises a material selected from the group consisting of a metal, a metal alloy, a plastic, an amorphous polymer, glass, clay, ceramic, a thermoset, an epoxy, silica, carbon black, carbon fibers, nanoclay, nanotubes, boron, and any combination thereof.

6. The seal ring back-up device of claim 1, wherein the annular body comprises a material selected from the group consisting of polyphenylene sulfide, polyaryletherketone, an amorphous polymer, a polyimide, a polyamide, a sulfone, any derivative thereof, and any combination thereof.

7. The seal ring back-up device of claim 1, further comprising a surface coating disposed on the annular body, the surface coating being selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.

8. A sealing system, comprising:

a bore;

a piston extendable within the bore and thereby defining an extrusion gap between the bore and the piston;

a gland defined in at least one of the bore and the piston and providing a wall;

a seal ring arranged within the gland; and

a seal ring back-up device arranged within the gland in direct contact with the seal ring and providing an annular body having a top surface engageable with the seal ring, a bottom surface opposite the top surface and engageable with the wall, an inner surface, and an outer surface opposite the inner surface,

wherein a scarf cut is defined through the annular body and extends between the inner and outer surfaces at an angle relative to the top surface.

9. The sealing system of claim 8, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, the opposing sloped faces being slidingly engageable with one another during operation.

10. The sealing system of claim 8, wherein the bottom surface and the wall are each wedge shaped.

11. The sealing system of claim 8, wherein the top surface comprises a surface contour shape selected from the group consisting of flat, convex, concave, angled, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

12. The sealing system of claim 8, wherein the annular body comprises a material selected from the group consisting of a metal, a metal alloy, a plastic, an amorphous polymer, glass, clay, ceramic, a thermoset, an epoxy, silica, carbon black, carbon fibers, nanoclay, nanotubes, boron, polyphenylene sulfide, polyaryletherketone, an amorphous polymer, a polyimide, a polyamide, a sulfone, any derivative thereof, and any combination thereof.

13. The sealing system of claim 8, further comprising a surface coating disposed on the annular body, the surface coating being selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.

14. The sealing system of claim 8, wherein the seal ring is bonded to the seal ring back-up device.

15. A method, comprising:

arranging a seal ring within a gland defined within one of a bore and a piston, the piston being extendable within the bore and thereby defining an extrusion gap between the bore and the piston;

arranging a seal ring back-up device within the gland and in direct contact with the seal ring, the seal ring back-up device providing an annular body having a top surface, a bottom surface opposite the top surface, an inner surface, and an outer surface opposite the inner surface, wherein a scarf cut is defined in the annular body and extends between the inner and outer surfaces at an angle relative to the top surface;

forcing the seal ring against the top surface as an external pressure increases and thereby forcing the bottom surface against a wall defined in the gland; and

closing the extrusion gap with the seal ring back-up device as the bottom surface is forced against the wall defined and thereby preventing the seal ring from deforming into the extrusion gap.

16. The method of claim 15, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, and wherein arranging the seal ring back-up device within the gland comprises:

separating the opposing sloped faces to increase an inner diameter of the seal ring back-up device; and

extending the piston through the seal ring back-up device until the seal ring back-up device locates the gland.

17. The method of claim 15, wherein the scarf cut provides opposing sloped faces each angled at the angle relative to the top surface, and wherein closing the extrusion gap with the seal ring back-up device comprises slidingly engaging the opposing sloped faces on one another.

18. The method system of claim 15, wherein the bottom surface and the wall are each wedge shaped and forcing the bottom surface against the wall comprises slidingly engaging the bottom surface against the wall.

19. The method of claim 15, wherein forcing the seal ring against the top surface comprises forcing the seal ring against a surface contour shape provided on the top surface, the surface contour shape being selected from the group consisting of flat, convex, concave, angled, stepped at the outer surface, chamfered at the outer surface, and any combination thereof.

20. The method of claim 15, wherein arranging the seal ring back-up device within the gland is preceded by coating the annular body with a surface coating selected from the group consisting of a corrosion inhibitor, a corrosion resistant material, a friction reducer, a wear reducer, ceramic, and any combination thereof.