

METAL FACE SEAL

Field of the Invention

This invention relates in general to earth-boring drill bits, and in particular to a bit that has a metal face bearing seal.

Background of the Invention:

A typical roller cone earth boring bit, such as used to drill wells, has three cones that roll around a common axis. The cones are mounted to bearing pins that depend from head sections. A seal contains lubricant within the cavity of the cone surrounding the bearing pin. A compensator in communication with the lubricant equalizes the pressure of the lubricant with the drilling fluid hydrostatic pressure on the exterior of bit. The purpose of seal is to prevent the entry of foreign debris from the exterior of the bit that can enter and damage the earth boring bit. The head sections are welded together to form a body that is threaded at the upper end for connection to a drill string.

One type of seal is disclosed in U.S. Patent No. 6,142,249, to Zahradnik, for a rigid metal face bearing seal with a secondary seal to partially seal against debris from the exterior of the bit. Despite the improvements achieved with the secondary seal, a void is formed between the metal face seal rigid ring, the energizing elastomer ring, and the secondary seal. This void then has to be filled with an oil or lubricant.

Summary of the Invention:

Briefly, the present invention is for an earth boring drill bit, which has a bit body with at least one bit leg, where the bit leg has a bearing pin. A cone is rotatably mounted over the

bearing pin, and the cone has a rearward facing seal surface that rotates with the cone. This rearward facing seal surface may be an end of an insert ring mounted inside of the cone. There is also a rigid seal ring that has a forward facing seal surface which engages the rearward facing surface of the cone in sliding engagement to form a seal as the cone rotates during drilling.

An elastomeric energizer ring is squeezed between an outer diameter portion of the bearing pin and the rigid seal ring. This placement causes the energizer ring to bias the rigid seal ring forward into contact with the rearward facing seal surface.

An elastomeric secondary seal ring has a rearward side in contact with a portion of the bit leg. It also has a forward side that has both an outer and inner portion. The outer portion of a forward side of the secondary seal ring is in contact with an outer side of the rigid seal ring. The inner portion of the forward side of the secondary seal ring is in contact with the energizer ring. Between the outer and inner portions of the secondary seal ring, there is a forward extending protrusion. This protrusion, which may be generally triangular in shape, fills substantially all of the void formed between the rigid seal ring, the elastomeric energizer ring, and the secondary seal ring.

In the embodiment shown, the secondary seal ring according to the present invention have an inner portion of the forward side that has an undeformed radius that is substantially equal to an undeformed radius of the rearward side of the elastomeric energizer ring. The rearward facing seal surface of the cone has an inner and outer diameter. The forward facing seal surface of the rigid seal ring also has an inner and outer diameter. The inner and outer diameters of the rearward facing surface of the cone may be substantially equal to the inner and outer diameters of the forward facing seal surface of the rigid seal ring.

Additionally, the portion of the bit leg engaged by a rearward side of the bearing pin may have a recess in the bit leg having a flat base bounded by radiused inner and outer ends. This allows the rearward side of the secondary seal ring, containing when undeformed a rearward extending rounded rib, to deform flat against the flat base when the secondary seal ring is installed.

In the embodiment shown, the portion of the bearing leg engaged by the elastomeric secondary seal ring may have a recess having an outer end formed at a radius that is between one-third and one-half of a nominal undeformed axial thickness of the elastomeric secondary seal ring.

In the preferred embodiment, the rigid seal ring has both an outer surface and an inner surface. The outer surface may have both a rearward portion and a forward portion where the rearward portion has a smaller outer diameter than the forward portion. The bearing pin may have a ridge that engages the rearward side of the energizer ring and the forward end of the elastomeric secondary seal ring adjacent to the concave section of the secondary seal ring. The secondary seal ring while undeformed may have a chamfered edge at the corner between the forward side and an outer portion of the elastomeric secondary seal ring.

Brief Description of the Drawings:

Figure 1 is a sectional view of an earth-boring bit having a seal constructed in accordance with this invention.

Figure 2 is an enlarged sectional view of the metal face seal in Figure 1, shown unassembled in the bit.

Figure 3 is an enlarged sectional view of the metal face seal in Figure 1, shown assembled in the bit.

Figure 4 is an enlarged cross-sectional view of the secondary seal ring of Figures 2 and 3 in a relaxed condition removed from the bit.

Detailed Description of the Invention:

Referring to Figure 1, an earth-boring drill bit or drill bit 11 has a bit body with at least one bit leg 13, and typically three legs. Each bit leg 13 has a depending bearing pin 15. A cone 16 rotatably mounts over each bearing pin 15. A metal face seal 19 seals lubricant within the cavity of cone 16 surrounding bearing pin 15. A compensator 17 is in communication with the lubricant for equalizing the pressure of the lubricant with the drilling fluid hydrostatic pressure on the exterior of bit 11.

Referring to Figure 2 and Figure 3, a forward end of rigid seal ring 21 engages a rearward end of insert or insert ring 23 to form a seal surface 25. Insert 23 is a cylindrical member secured within the cavity of cone 16 for rotation therewith. The rigid seal ring 21 includes an exterior surface with a rearward portion 22a and a forward portion 22b. Rearward portion 22a has a smaller outer diameter than forward portion 22b. A chamfer or shoulder is located at the intersection of the rearward portion 22a and the forward portion 22b. A radial distance from cone cavity 29 to the rearward portion 22a is approximately twice the distance from cone cavity 29 to forward portion 22b. The thickness of the rigid seal ring 21 at seal surface 25 is approximately the same as insert 23. The net result of thickening the base of the rigid seal ring 21 is to allow for a larger area of seal surface 25 over the prior art.

An elastomeric energizer ring 27, which may be an o-ring or other cross-sectional shaped ring, sits between the interior surface of the rigid seal ring 21 and gland surface 31 of bearing pin 15. Gland surface 31 in conjunction with the surface of cone cavity 29 defines a bearing seal gland between bearing pin 15 and cone 16. Gland surface 31 has a rounded protrusion or ridge

33 that engages the rearward portion of the elastomeric energizer ring 27 to reduce axial movement of the elastomeric energizer ring 27. Rounded protrusion 33 has the additional advantage of eliminating the need for sandblasting gland surface 31.

A secondary seal ring 35 contacts rounded protrusions 33. A concave portion 37 of the secondary seal ring 35 contacts the elastomeric energizer ring 27. The concave portion 37 has a rounded triangular shaped protrusion 38 (Figure 2) on its forward side that engages the elastomeric energizer ring 27 and the rigid seal ring 21. The rounded triangular shaped protrusion 38 is sized to fill substantially all of the triangular space 40 between the rigid seal ring 21, the secondary seal ring 35, and the elastomeric energizer ring 27. Reducing the volume of triangular space 40 eliminates the need for filler oil of the prior art because up to 95% of triangular space 40 is filled by the triangular protrusion 38 of the secondary seal ring 35.

A last machined surface 39 where the bit leg 13 engages the bearing pin 15 includes a machined groove 41, the depth of which is between one third to one half the nominal undeformed axial thickness T of the secondary seal ring 35, to accommodate the secondary seal ring 35 between the last machined surface 39 and the rigid seal ring 21. Machined groove 41 has an outer wall 41a that has a cylindrical portion intersecting the last machined surface 39. A line tangent to outer wall 41a at the intersection with the last machined surface 39 is perpendicular to the last machined surface 39. The secondary seal ring 35 engages the outer wall 41a. Additionally, the last machined surface 39 includes an outer end formed at a radius that is between one-third and one-half of the nominal undeformed axial thickness T of the secondary seal ring 35.

The purpose of the secondary seal ring 35 is to seal against entry of foreign debris, particularly drilling mud particles from the exterior of the bit, that can enter the seal gland between the gaps formed between the last machined surface 39 and back face 43 of cone 16.

Cone cavity 29 has a reduced diameter portion 44 onto which insert 23 is captured. A sloped transition 45 joins cone cavity 29 to the reduced diameter portion 44. Sloped transition 45 is located slightly forward of seal surface 25. The location of the sloped transition 45 allows for extended life of the drill bit by reducing the accumulation of particulate adjacent to seal surface 25.

Referring to Figure 4, Figure 4 is an enlarged cross-sectional view of the secondary seal ring 35. Preferably, the secondary seal ring 35 is a continuous ring formed of nitrile elastomer material of about 40-45 durometer (Shore A) and a modulus of elasticity of about 100-600 psi/in/in, preferably between 200-300 psi/in/in. The unique shape of the secondary seal ring 35 maximizes the filled volume of the assembled drill bit and to prevent the introduction of foreign debris into the seal gland.

The concave portion 37 of the secondary seal ring 35 allows for the secondary seal ring to better mate with the elastomeric energizer ring 27 in the assembled drill bit. This is achieved by the concave portion 37 of the secondary seal ring 35 having an undeformed interior radius similar to that of an undeformed exterior radius of the elastomeric energizer ring 27. This enlarged area of contact between the secondary seal ring 35 and the elastomeric energizer ring 27 work to minimize any volume formed between the secondary seal ring 35, the elastomeric energizer ring 27 and the rigid seal ring 21.

The secondary seal ring 35 also contains a raised edge 47 and a rounded rib 48 that have widths between 25% and 35% of the nominal undeformed axial thickness T of the secondary seal

ring 35, and a height between 10% and 15% of the nominal undeformed axial thickness T of the secondary seal ring 35. The purpose of the raised edge 47 and rounded rib 48 is to form areas of high-stress to deter the entry of foreign fluid, particles and/or debris into the seal gland when the secondary seal ring 35 is in place in an assembled unit.

The exterior face of the secondary seal ring 35 has a chamfered outer edge 49 to reduce wear and tear on the secondary seal ring 35. Chamfering the outer edge 49 between 5 and 25 degrees has the advantage of increasing the life of the secondary seal ring 35 by removing sharp corners subject to damage from particulate entering the drill bit between the last machined surface 39 and the back face 43 of cone 16.

Axial thickness T of the secondary seal ring 35 is greater than the gap formed between the machined groove 41 and the end of the rigid seal ring 21. The intent is to provide a sufficient "squeezing" effect on the secondary seal ring 35 between the machined groove 41 and the rigid seal ring 21. A net squeezing effect is approximately between 20% and 25% of the uncompressed or relaxed thickness T of the secondary seal ring 35 using nominal values with cone 16 forced outward on bearing pin 15.

Having described the invention above, various modifications of the techniques, procedures, components and equipment will be apparent to those skilled in the art. It is intended that all such variations within the scope and spirit of the appended claims be embraced thereby.

Claims

1. An earth boring drill bit comprising:

a bit body with one bit leg;

the bit leg having a bearing pin;

a cone rotatably mounted over the bearing pin;

the cone having a rearward facing seal surface that rotates with the cone;

a rigid seal ring having a forward facing seal surface that engages the rearward facing surface in sliding engagement to form a seal;

an elastomeric energizer ring squeezed between an outer diameter portion of the bearing pin and the rigid seal ring to bias the rigid seal ring forwardly;

an elastomeric secondary seal ring having a rearward side in contact with a portion of the bit leg, an outer portion of a forward side in contact with an outer side of the rigid seal ring, and an inner portion of the forward side in contact with the elastomeric energizer ring; and

a forward extending protrusion between the inner portion and the outer portion of the forward side of the elastomeric secondary seal ring, the forward extending protrusion filling substantially all of a void between the rigid seal ring and the elastomeric energizer ring.

2. The bit according to claim 1, wherein:

the rearward facing seal surface of the cone comprises an end of an insert ring mounted in the cone;

the rigid seal ring has an inner diameter at its forward end that is substantially equal to an inner diameter of the end of the insert ring; and

the rigid seal ring has an outer diameter at its forward end that is substantially equal to an outer diameter of the end of the insert ring.

3. The bit according to claim 2, wherein the cone has a cavity with a reduced diameter that engages the insert ring forward of seal between the forward facing seal surface and the rearward facing seal surface.

4. The bit according to claim 1, wherein the inner portion of the forward side of the elastomeric secondary seal ring has an undeformed radius that is substantially equal to an undeformed radius of the rearward side of the elastomeric energizer ring.

5. The bit according to claim 1, wherein the forward extending protrusion on the elastomeric secondary seal ring is generally triangular.

6. The bit according to claim 1, wherein a portion of the bearing leg engaged by the elastomeric secondary seal ring comprises a recess having an outer end formed at a radius that is between one-third and one-half of a nominal undeformed axial thickness of the elastomeric secondary seal ring.

7. The bit according to claim 1, wherein the portion of the bit leg engaged by a rearward side of the bearing pin comprises a recess in the bit leg having a flat base bounded by radiused inner and outer ends.

8. The bit according to claim 7, wherein the rearward side of the elastomeric secondary seal ring while undeformed has a rearward extending rounded rib that is deformed flat against the flat base when the elastomeric secondary seal ring is installed.

9. The bit according to claim 1, wherein the rigid seal ring further comprises:

an outer surface and an inner surface;

the outer surface having both a rearward portion and a forward portion, wherein the rearward portion has a smaller outer diameter than the forward portion.

10. The bit according to claim 1, further comprising a ridge formed on the bearing pin and in engagement with a rearward side of the elastomeric energized ring and an inner end of the elastomeric secondary seal ring.

11. The bit according to claim 1, wherein the secondary seal ring while undeformed has a chamfered edge at the corner between the forward side and an outer portion of the elastomeric secondary seal ring.

12. An earth boring drill bit comprising:

a bit body with one bit leg;

the bit leg having a bearing pin;

a cone rotatably mounted over the bearing pin;

the cone having a rearward facing seal surface that rotates with the cone;

the rearward facing seal surface of the cone comprises an end of an insert ring mounted in the cone;

a rigid seal ring having a forward facing seal surface that engages the rearward facing surface in sliding engagement to form a seal;

the rigid seal ring having an inner diameter at its forward end that is substantially equal to an inner diameter of the end of insert ring;

the rigid seal ring having an outer diameter at its forward end that is substantially equal to an outer diameter of the end of the insert ring.

an elastomeric energizer ring squeezed between an outer diameter portion of the bearing pin and the rigid seal ring to bias the rigid seal ring forwardly; and

an elastomeric secondary seal ring having a rearward side in contact with a portion of the bit leg, an outer portion of a forward side in contact with an outer side of the rigid seal ring, and an inner portion of the forward side in contact with the elastomeric energizer ring.

13. The bit according to claim 12, wherein the elastomeric secondary seal ring has a forward extending protrusion between the inner portion and the outer portion of the forward side of the elastomeric secondary seal ring, the forward extending protrusion filling substantially all of the void between the rigid seal ring and the elastomeric energizer ring

14. The bit according to claim 12, wherein the inner portion of the forward side of the elastomeric secondary seal ring has an undeformed radius that is substantially equal to an undeformed radius of the rearward side of the elastomeric energizer ring.

15. The bit according to claim 12, wherein the portion of the bit leg engaged by a rearward side of the bearing pin comprises a recess in the bit leg having a flat base bounded by radiused inner and outer ends.

16. The bit according to claim 15, wherein a portion of the bearing leg engaged by the elastomeric secondary seal ring comprises a recess having an outer end formed at a radius that is between one-third and one-half of a nominal undeformed axial thickness of the elastomeric secondary seal ring.

17. The bit according to claim 15, wherein the rearward side of the elastomeric secondary seal ring while undeformed has a rearward extending rounded rib that is deformed flat against the flat base when the elastomeric secondary seal ring is installed.

18. The bit according to claim 12, wherein the rigid seal ring further comprises:

an outer surface and an inner surface;

the outer surface having both a rearward portion and a forward portion wherein the rearward portion has a smaller outer diameter than the forward portion.

19. The bit according to claim 12, further comprising a ridge formed on the bearing pin and in engagement with a rearward side of the elastomeric energized ring and a forward end of the elastomeric secondary seal ring.

20. An earth boring drill bit comprising:

a bit body with one bit leg;

the bit leg having a bearing pin;

a portion of the bit leg engaged by a rearward side of the bearing pin comprising a recess in the bit leg having a flat base bounded by radiused inner and outer ends;

a cone rotatably mounted over the bearing pin;

the cone having a rearward facing seal surface that rotates with the cone;

a rigid seal ring having a forward facing seal surface engaging the rearward facing surface in sliding engagement to form a seal;

an elastomeric energizer ring squeezed between an outer diameter portion of the bearing pin and the rigid seal ring to bias the rigid seal ring forwardly;

an elastomeric secondary seal ring having a rearward side in contact with the portion of the bit leg, an outer portion of a forward side in contact with an outer side of the rigid seal ring, and an inner portion of the forward side in contact with the elastomeric energizer ring;

the inner portion of the forward side of the elastomeric secondary seal ring having an undeformed radius that is substantially equal to an undeformed radius of the rearward side of the elastomeric energizer ring;

the rearward side of the elastomeric secondary seal ring while undeformed has a rearward extending rounded rib that is deformed flat against the flat base when the elastomeric secondary seal ring is installed;

a forward extending protrusion between the inner portion and the outer portion of the forward side of the elastomeric secondary seal ring, the forward extending protrusion filling substantially all of the void between the rigid seal ring and the elastomeric energizer ring; and

the secondary seal ring while undeformed has a chamfered edge at the corner between the forward side and an outer portion of the elastomeric secondary seal ring; and

a ridge formed on the bearing pin and in engagement with a rearward side of the elastomeric energized ring and a forward end of the elastomeric secondary seal ring.