(54) Title: NECK SEAL FOR ROLLING MILL OIL FILM BEARING

(57) Abstract: A seal (64) for use on the tapered section of a roll neck in a rolling mill, comprising a flexible and resilient circular seal body (66) having a cylindrical outer surface (72) delimited at least one end by a radially outwardly extending flange (75). The flange has first and second sides (74a, 74b) terminating respectively at beveled first and second faces (74c, 74d) that converge at an outer sealing edge (74e). A hinge (76) is provided in the flange (75). The radial distance R2 between the hinge (76) and a reference plane parallel to the cylindrical outer surface (72) and containing the outer sealing edge (74e) is about 0.4 to 0.7 times the radial distance R1 between the reference plane and the cylindrical outer surface (72).
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NECK SEAL FOR ROLLING MILL OIL FILM BEARING

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority from Provisional Application Serial No. 60/509,214 filed October 7, 2003.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to flexible and resilient elastomeric seals, and is concerned in particular with an improvement to seals of the type employed on the tapered sections of roll necks journalled for rotation in rolling mill oil film bearings.

2. Description of the Prior Art

FIG. 1 illustrates a prior art neck seal 10 of the type described in U.S. Pat. No. 4,586,720 (Simmons et al.). The seal is molded of a flexible resilient elastomer and has a circular seal body 12 internally reinforced by an embedded combination of a coiled spring 14 and a steel cable 16. The seal body has oppositely protruding water-side and oil-side lips 18, 20, a cylindrical outer surface 21 delimited at one end by an oil-side flange 22 adjacent to another second oil-side flange 24 commonly referred to as a “flinger”, and a water-side flange 26 delimiting the opposite end of surface 21.

The flanges 22, 26 are provided respectively with angularly disposed peripheral lips 28, 30. The lip 28 projects from flange 22 in the direction of the flinger flange 24, which in turn projects in the same direction at an angle with respect to flange 22 to define a space "S" therebetween open to the surrounding atmosphere.

As shown in FIG. 2, the seal 10 is adapted to be mounted on the tapered section 34 of a rolling mill roll neck 36 which in turn is rotatably supported in an oil film bearing. The bearing includes a sleeve 38 fixed to the roll neck by conventional means (not shown) for
rotation therewith. The sleeve 38 has an outer cylindrical bearing surface which is journalled for rotation within an interior bearing surface of a fixed bushing 40. The bushing is carried in a bearing chock 42.

The sleeve rotates with the roll neck while the bearing chock and the bushing remain stationary. Highly viscous oil is fed continuously between the bearing surfaces of the sleeve 38 and bushing 40. A circular extension 44 of the bearing chock provides a sump 46 in which the oil emerging from between the bearing surfaces is continuously collected. The oil is drawn away from the sump through a suitable piping connection (not shown) to be cooled and filtered before being recycled back to the bearing surfaces.

Where the roll is operating under "wet" conditions, water is constantly flooding over the roll barrel 48 and down over its end face 50. In spite of the centrifugal forces which tend to throw the water off of the roll, some of the water tends to work its way along the roll neck in the direction of the bearing. The objective of the seal assembly generally indicated at 52 and the flexible neck seal 10 which forms a component part thereof is to prevent any of the water from infiltrating into the bearing and contaminating the bearing oil while at the same time preventing loss of oil from the bearing.

In addition to the flexible seal 10, the seal assembly 52 includes a rigid circular seal end plate 54 which is mounted on and fixed relative to the circular extension 44 of the bearing chock 42. The seal end plate has a radially inwardly extending rigid circular flange or “dam” 56 which is perpendicular to the bearing axis. The inner edge of the dam is spaced radially from the cylindrical outer surface 21 of the flexible seal body. The seal end plate further includes shoulders 58 extending in opposite directions from the base of the dam 56. Each of the shoulders 58 has a cylindrical shoulder surface 60 which is parallel to the bearing axis. The cylindrical shoulder surfaces 60 surround the flexible seal flanges 22, 26, and are arranged to be slidingly contacted by their respective flexible lips 28, 30.

The seal assembly 52 also includes an inner seal ring 62 with resilient buttons 64 engaging the end face 50 of the roll. The inner edge of the inner seal ring contacts the
flexible seal body 12 at the juncture of the lip 18 and flange 26.

During a rolling operation, the above-described arrangement will operate in the following manner: the inner seal ring 62, flexible neck seal 10 and sleeve 38 will rotate with the roll neck. The seal end plate 54, chock 42 and bushing 40 will remain stationary. Lubricating oil will constantly flow from between the bearing surfaces of the sleeve 38 and bushing 40. Most of this oil will be turned back by the flinger 24 on the neck seal and will thus be directed to the sump 46. Oil which succeeds in passing by the flinger 24 will be turned back by the rotation oil-side flange 22 and will be prevented from escaping between the flange 22 and the shoulder surface 60 by the flexible lip 28 which sealingly engages the shoulder surface. Likewise, the major portion of the water applied to the roll will be turned back by the rotating inner seal ring 62. Any water which succeeds in passing by the inner seal ring will be turned back by the rotating water-side flange 26 on the neck seal and will be prevented from passing between the flange and its surrounding shoulder surface by the flexible lip 30.

Experience has shown that there are a number of disadvantages associated with the above-described prior art neck seal 10. These include:

1) The wide contact profile between the sealing lips 28, 30 and the seal end plate does not allow a true hydrodynamic fluid film to be established at the dynamic interface. This leads to a poor lubrication regime and high wear rates.

2) The thin flexible sealing lips offer little resistance to abrasive wear.

3) The thin flexible sealing lips are prone to high temperature plastic set, reducing sealing contact stresses and limiting the response of the lip to applied roll offset.

SUMMARY OF THE INVENTION

The invention differs fundamentally from traditional roll neck seals in the design philosophy of the oil-side and water-side flanges and their respective sealing lips. These lips,
extending to the outer diameter of the component, are designed to act in concert with hinges incorporated into the flanges such that a hydrodynamic fluid film is established between the sealing lips and the surfaces of the seal end plate with which they are in contact under all possible radial roll offset conditions. The fluid film provides a dynamic barrier to the passage of media from the fluid side to the air side, effectively pumping the medium continuously back to the fluid side.

Other features and advantages of the present invention will now be described in greater detail with reference to the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a sectional view through a conventional seal;

Figure 2 is a sectional view through an oil film bearing incorporating the seal shown in Figure 1;

Figure 3 is a sectional view through a seal in accordance with the present invention;

Figure 4 is a partial sectional view showing the seal of Figure 3 installed in an oil film bearing assembly.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

With reference to Figure 3, a seal 64 in accordance with the present invention is again molded of a flexible resilient elastomer and has a circular body 66 with oppositely protruding water-side and oil-side lips 68, 70, and a cylindrical outer surface 72. Surface 72 is delimited at at least one end by an oil side flange 74', and is preferably delimited at the opposite end by a water-side flange 74". The flanges 74', 74" each have first sides 74a which in use are exposed to liquids (oil or water), and second sides 74b which confront one another and which in use are exposed to air in the axial gap between the flanges 74', 74". The first and second flange sides terminate respectively at beveled first and second faces 74c, 74d that converge at outer edges 74e to form sealing lips 75. When the seal is in an unstressed state, i.e., not
axially mounted on a roll neck or radially confined by a seal end plate, the outer edges 74e are located in a reference plane “P” parallel to and spaced from surface 72 by a radial distance R₁. In the unstressed state, the beveled faces 74c, 74d respectively form contact angles \( \alpha_1, \beta_1 \), with the reference plane P.

The flanges 74', 74" are additionally provided with hinges 76, preferably configured as grooves in the first sides 74a. The hinges 76 are spaced from the reference plane P by a radial distance R₂.

When the seal 64 is installed in a bearing assembly, as shown in Figure 4, the flanges 74', 74" are radially confined by the shoulder surfaces 60 of the seal end plate 54. This causes the flanges to deflect about the hinges 76, which in turn results in changed contact angles \( \alpha_2, \beta_2 \) between the faces 74c, 74d and the shoulder surfaces 60.

In order to insure that a hydrodynamic fluid film is maintained between the sealing lips 75 and the shoulder surfaces 60 when the seal is installed and functioning in a bearing assembly, it has been determined that the contact angle \( \alpha_2 \) must be about 35° to 60°, and the contact angle \( \beta_2 \) must be about 12° to 35°.

In order to achieve this objective, when the seal is in an unstressed state as depicted in Figure 3, a critical synergistic relationship is required between the radial distance R₂ and the contact angles \( \alpha_1, \beta_1 \). More particularly, it has been determined that \( \alpha_1 \), should be about 15° to 30°, \( \beta_1 \) should be about 40° to 60°, and R₂ should be about 0.4 to 0.7 times R₁.

By incorporating these features into the neck seal, the following advantages are realized:

1) Sealing effectiveness is increased due to the establishment and sustaining of a hydrodynamic fluid film between the edges 74e of the sealing lips 75 and the seal end plate.

2) Seal lip wear is reduced through an improved lubrication regime at the sealing edges.

3) Seal life is extended through a robust lip geometry.
4) The positioning and resilience of the hinges 76 will reduce the risk of plastic lip set and the associated loss in roll offset accommodation.

In light of the foregoing, it will be understood by those skilled in the art that various changes and modifications may be made to the disclosed embodiment without departing from the spirit of the invention or the scope of the appended claims. By way of example only, for so-called "dry" bearing installations where cooling water is not applied to the rolls, a seal could be provided with only one oil side flange. The flange hinges may be configured differently, as may other features of the seal body.

We claim:
1. A seal for use on the tapered section of a roll neck in a rolling mill, comprising:
   a flexible circular seal body having a cylindrical outer surface delimited at at least one end by a radially outwardly extending flange, said flange having first and second sides terminating respectively at beveled first and second faces that converge at an outer edge;
   a hinge in said flange, the radial distance between said hinge and a reference plane parallel to said cylindrical outer surface and containing said outer edge being about 0.4 to 0.7 times the radial distance between said reference plane and said cylindrical outer surface.

2. The seal of claim 1 wherein said cylindrical outer surface is delimited by the second side of said flange, and wherein said hinge is configured as a groove in the first side of said flange.

3. The seal of claims 1 or 2 wherein said first face forms an angle of about 15° to 30° with respect to said reference plane.

4. The seal of claim 3 wherein said second face forms an angle of about 40° to 60° with respect to said reference plane.

5. A seal for use on a tapered section of a roll neck in a rolling mill, said seal comprising:
   a flexible circular seal body having a cylindrical outer surface delimited at opposite ends by radially outwardly extending
flanges, said flanges having oppositely facing first sides and
contfronting second sides, said first and second sides
terminating respectively at angled first and second faces that
converge at outer edges; and

grooves in the first sides of said flanges, the radial distances
between said grooves and a reference plane parallel to said
cylindrical outer surface and containing said outer edges
being about 0.4 to 0.7 times the radial distance
between said reference plane and said cylindrical outer
surface.

6. The seal of claim 5 wherein said first faces form angles of about 15° to 30°
with said reference plane.

7. The seal of claim 6 wherein said second faces form angles of about 40° to 60°
with said reference plane.

8. A seal for use on a tapered section of a roll neck in a rolling mill, said seal
comprising:

    a flexible circular seal body having a cylindrical outer surface
delimited at opposite ends by radially outwardly extending
flanges, said flanges having oppositely facing first sides and
confronting second sides, said first and second sides
terminating respectively at angled first and second faces that
converge at outer edges; and

grooves in the first sides of said flanges, the radial distances
between said grooves and a reference plane parallel to said
cylindrical outer surface and containing said outer edges
being about 0.4 to 0.7 times the radial distance
between said reference plane and said cylindrical outer
surface, said first faces forming angles of about 15° to 30° and
said second faces forming angles of about 40° to 60° with said
reference plane.
# INTERNATIONAL SEARCH REPORT

**A. CLASSIFICATION OF SUBJECT MATTER**

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**B. FIELDS SEARCHED**

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<td>IPC 7 B21B F16J</td>
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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>A</td>
<td>EP 1 136 142 A (KVAERNER ENGINEERING &amp; CONSTRUCTION UK LIMITED) 26 September 2001 (2001-09-26) figures 1,2</td>
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Further documents are listed in the continuation of box C.

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**Name and mailing address of the ISA**

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Authorized officer

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