DETAILED DESCRIPTION

[0019] Presently disclosed embodiments are directed to systems and methods for lubricating rolling bearing elements within a rolling bearing element assembly configured to support a rotary element (e.g., shaft) in oscillatory motion. The rolling bearing element assembly includes an inner race, an outer race, and a plurality of rolling bearing elements disposed therebetween. The inner race and outer race may be annular disks concentrically aligned with each other and with the rotary equipment being supported. The rolling bearing elements are circumferentially spaced (e.g., positioned at equally spaced angles) about the bearing system axis via a bearing cage disposed in the annular volume between the inner and outer races. The rolling bearing element assembly is generally configured such that, when the rotary equipment is rotated in a first direction about the bearing system axis, the rolling bearing elements in their circumferential spacing also revolve around the bearing system axis in the first direction. However, when the rotary equipment is rotated in a second direction opposite the first direction, the rolling bearing element assembly prevents or resists revolution of the rolling bearing elements about the bearing system axis in the second direction. Specifically, the rolling bearing elements may rotate about their own axes and even slip such that they revolve slightly in the second direction about the bearing system axis when the rotary equipment rotates in the second direction. However, the distance of this revolution may be negligible in comparison with the revolution of the rolling bearing elements in the first direction. Accordingly, when the rotary equipment oscillates, the rolling bearing elements disposed between the inner and outer races generally move about the bearing system axis in a single direction.

[0020] The presently disclosed embodiments may provide relatively increased distribution and reapplication of lubricant (e.g., oil, grease, etc.) between the inner and outer races and the rolling bearing elements, as compared to systems that allow the rolling bearing elements themselves to oscillate about the bearing system axis to accommodate the oscillatory motion. It is now recognized that traditional rolling bearing

element systems that allow the rolling bearing elements to oscillate back and forth between the inner and outer races may encounter certain difficulties leading to inefficient bearing operation. For example, if the angular rotation of the rotary equipment about the bearing system axis is small, the rolling bearing elements may not move far enough about the bearing assembly to pick up and redistribute the lubricant left over from adjacent rolling bearing elements. This could lead to inadequate lubrication of the rolling bearing elements and inefficient operation of the rolling bearing element assembly. Presently disclosed embodiments include entirely mechanical components that facilitate motion of the bearings in just a single direction revolving about the bearing system axis, instead of the oscillatory motion described above, thereby increasing the mechanical application of lubricant throughout the bearing system.

[0021] FIG. 1 is a schematic illustration of one such bearing assembly 10 that transfers oscillatory motion of attached rotary equipment into one directional motion of rolling bearing elements 12 disposed therein. The illustrated bearing assembly 10 includes an inner race 14, an outer race 16, the plurality of rolling bearing elements 12 disposed between the inner and outer races 14 and 16, a bearing cage 18, and a plurality of indexing elements (e.g., sprags 20). The entire bearing assembly 10 is arranged concentrically about a bearing system axis 22.

[0022] In some embodiments, the inner race 14 is coupled to rotary equipment, such as a rotating shaft, during operation of the rolling bearing element assembly 10, and the outer race 16 is coupled to stationary equipment used to support the rotary equipment. Although the following discussion generally focuses on the bearing assembly 10 being driven by rotary equipment coupled to the inner race 14, it should be noted that, in other embodiments, the rolling bearing element assembly 10 may be driven by rotary equipment coupled to the outer race 16.

[0023] The rolling bearing elements 12 disposed between the races 14 and 16 may include ball bearings (arranged in a single row or double rows), cylindrical bearings (e.g., pins), tapered roller bearings, needle roller bearings, spherical roller bearings, and any

CLAIMS:

1. A system, comprising:

a rolling bearing element assembly configured to enable rotation of a rotary element relative to a stationary element, the rotation being about a bearing system axis of the rolling bearing element assembly;

wherein the rolling bearing element assembly comprises an inner race, an outer race, a plurality of rolling bearing elements disposed between the inner and outer races, and a bearing cage configured to hold the rolling bearing elements such that the rolling bearing elements are circumferentially spaced about the bearing system axis;

wherein the rolling bearing element assembly is configured to facilitate oscillatory motion of the rotary element relative to the stationary element such that, when the rotary element rotates in a first direction about the bearing system axis, the rolling bearing elements revolve about the bearing system axis in the first direction, and when the rotary element rotates in a second direction opposite the first direction about the bearing system axis, revolution of the rolling bearing elements about the bearing system axis in the second direction is resisted or prevented.

2. The system of claim 1, wherein the rotary element is coupled to the inner race, and wherein the stationary element is coupled to the outer race.

3. The system of claim 1, wherein the rotary element is coupled to the outer race, and wherein the stationary element is coupled to the inner race.

4. The system of claim 1, wherein the rolling bearing element assembly comprises a spring-loaded indexing element configured to engage with a contact surface to allow revolution of the rolling bearing elements about the bearing system axis when the rotary element is rotating in the first direction and to resist revolution of the rolling bearing elements about the bearing system axis in the second direction when the rotary element is rotating in the second direction.

5. The system of claim 4, wherein the indexing element is coupled to the rolling bearing elements via the bearing cage, and wherein the contact surface is disposed on the inner race.

6. The system of claim 4, wherein the indexing element is coupled to the rolling bearing elements via the bearing cage, and wherein the contact surface is disposed on the outer race.

7. The system of claim 4, wherein the indexing element is coupled to a seal disposed between the inner and outer races, and wherein the contact surface comprises a surface of a bearing cage coupled to the plurality of rolling bearing elements.

8. The system of claim 4, wherein the indexing element and the contact surface are configured such that a frictional force between the indexing element and the contact surface holds the indexing element and the contact surface in engagement.

9. The system of claim 4, wherein the contact surface comprises ratchet teeth.

10. The system of claim 4, wherein the indexing element comprises a leading edge rotatably coupled to a component of the rolling bearing element assembly and a trailing edge configured to engage the contact surface.

11. The system of claim 4, wherein the indexing element is configured to slide relative to the contact surface when the rotary element is rotating in the second direction.

12. The system of claim 1, wherein the rolling bearing element assembly comprises a sealed rolling bearing element assembly.

13. A bearing system, comprising:

an outer race disposed in alignment with a bearing system axis;

an inner race concentric with the outer race and having an outer diameter less than an inner diameter of the outer race, wherein the inner race is configured to rotate relative to the outer race about the bearing system axis;

a rotary element coupled to one of the inner race or the outer race;

a plurality of rolling bearing elements disposed between and in rolling contact with the inner race and the outer race;

a bearing cage coupled to the plurality of rolling bearing elements, wherein the bearing cage is configured to keep the plurality of rolling bearing elements circumferentially spaced about the bearing system axis;

a spring loaded indexing element with a first end rotatably coupled to the bearing cage and a second end in contact with a contact surface of the inner race or the outer race;

wherein the indexing element is configured to engage the contact surface via the second end to enable rotation of the bearing cage in a first direction about the bearing system axis when the rotary element is rotating in the first direction, and wherein the indexing element is configured to slide relative to the contact surface to prevent or resist rotation of the bearing cage in a second direction about the bearing system axis when the rotary element is rotating in the second direction opposite the first direction.

14. The bearing system of claim 13, wherein a frictional force between the second end of the indexing element and the contact surface allows rotation of the bearing cage and the plurality of rolling bearing elements in the first direction when the rotary element is rotating in the first direction.

15. The bearing system of claim 13, wherein the contact surface comprises ratchet teeth, and wherein the indexing element is spring-loaded to interlock with the teeth when the rotary element is rotating in the first direction.

16. The bearing system of claim 13, comprising a plurality of spring-loaded indexing elements each coupled to the bearing cage and disposed circumferentially about the bearing system axis.

17. The bearing system of claim 13, wherein the indexing element comprises an asymmetric shape wherein the first end comprises a rounded leading edge and the second end comprises a trailing edge configured to engage the inner race.

18. The bearing system of claim 13, wherein the rotary element is coupled to the inner race and wherein the inner race comprises the contact surface.

19. The bearing system of claim 13, wherein the rotary element is coupled to the outer race and wherein the outer race comprises the contact surface.

20. A method, comprising:

facilitating oscillatory rotation of a rotary element about a bearing system axis and relative to a stationary element via a rolling bearing element assembly, wherein the rolling bearing element assembly comprises an inner race coupled to the rotary element, an outer race coupled to the stationary element, and a plurality of rolling bearing elements disposed between the inner and outer races;

allowing the rolling bearing elements to revolve about the bearing system axis in a first direction when the rotary element rotates in the first direction about the bearing system axis; and

preventing or resisting revolution of the rolling bearing elements about the bearing system axis in a second direction when the rotary element rotates in the second direction about the bearing system axis.

21. The method of claim 20, wherein allowing the rolling bearing elements to revolve about the bearing system axis in the first direction comprises engaging a spring-

loaded indexing element coupled to the rolling bearing elements with a contact surface of the inner race when the rotary element rotates in the first direction, and wherein preventing or resisting the rolling bearing elements from revolving in the second direction comprises sliding the contact surface of the inner race relative to the indexing element when the rotary element rotates in the second direction.

22. The method of claim 20, wherein allowing the rolling bearing elements to revolve about the bearing system axis in the first direction comprises engaging a spring-loaded indexing element coupled to the rolling bearing elements with a contact surface of the outer race when the rotary element rotates in the first direction, and wherein preventing or resisting the rolling bearing elements from revolving in the second direction comprises sliding the contact surface of the outer race relative to the indexing element when the rotary element rotates in the second direction.

23. The method of claim 20, comprising engaging the rolling bearing elements with the inner race when the rotary element rotates in the first direction, and allowing the rolling bearing elements to slide relative to the inner race when the rotary element rotates in the second direction.

DETAILED DESCRIPTION

[0019] Presently disclosed embodiments are directed to systems and methods for lubricating rolling bearing elements within a rolling bearing element assembly configured to support a rotary element (e.g., shaft 15) in oscillatory motion. The rolling bearing element assembly includes an inner race, an outer race, and a plurality of rolling bearing elements disposed therebetween. The inner race and outer race may be annular disks concentrically aligned with each other and with the rotary equipment being supported. The rolling bearing elements are circumferentially spaced (e.g., positioned at equally spaced angles) about the bearing system axis via a bearing cage disposed in the annular volume between the inner and outer races. The rolling bearing element assembly is generally configured such that, when the rotary equipment is rotated in a first direction about the bearing system axis, the rolling bearing elements in their circumferential spacing also revolve around the bearing system axis in the first direction. However, when the rotary equipment is rotated in a second direction opposite the first direction, the rolling bearing element assembly prevents or resists revolution of the rolling bearing elements about the bearing system axis in the second direction. Specifically, the rolling bearing elements may rotate about their own axes and even slip such that they revolve slightly in the second direction about the bearing system axis when the rotary equipment rotates in the second direction. However, the distance of this revolution may be negligible in comparison with the revolution of the rolling bearing elements in the first direction. Accordingly, when the rotary equipment oscillates, the rolling bearing elements disposed between the inner and outer races generally move about the bearing system axis in a single direction.

[0020] The presently disclosed embodiments may provide relatively increased distribution and reapplication of lubricant (e.g., oil, grease, etc.) between the inner and outer races and the rolling bearing elements, as compared to systems that allow the rolling bearing elements themselves to oscillate about the bearing system axis to accommodate the oscillatory motion. It is now recognized that traditional rolling bearing

element systems that allow the rolling bearing elements to oscillate back and forth between the inner and outer races may encounter certain difficulties leading to inefficient bearing operation. For example, if the angular rotation of the rotary equipment about the bearing system axis is small, the rolling bearing elements may not move far enough about the bearing assembly to pick up and redistribute the lubricant left over from adjacent rolling bearing elements. This could lead to inadequate lubrication of the rolling bearing elements and inefficient operation of the rolling bearing element assembly. Presently disclosed embodiments include entirely mechanical components that facilitate motion of the bearings in just a single direction revolving about the bearing system axis, instead of the oscillatory motion described above, thereby increasing the mechanical application of lubricant throughout the bearing system.

[0021] FIG. 1 is a schematic illustration of one such bearing assembly 10 that transfers oscillatory motion of attached rotary equipment into one directional motion of rolling bearing elements 12 disposed therein. The illustrated bearing assembly 10 includes an inner race 14, an outer race 16, the plurality of rolling bearing elements 12 disposed between the inner and outer races 14 and 16, a bearing cage 18, and a plurality of indexing elements (e.g., sprags 20). The entire bearing assembly 10 is arranged concentrically about a bearing system axis 22.

[0022] In some embodiments, the inner race 14 is coupled to rotary equipment, such as the shaft 15, during operation of the rolling bearing element assembly 10, and the outer race 16 is coupled to stationary equipment 17 used to support the rotary equipment (e.g., the shaft 15). Although the following discussion generally focuses on the bearing assembly 10 being driven by rotary equipment coupled to the inner race 14, it should be noted that, in other embodiments, the rolling bearing element assembly 10 may be driven by rotary equipment coupled to the outer race 16.

[0023] The rolling bearing elements 12 disposed between the races 14 and 16 may include ball bearings (arranged in a single row or double rows), cylindrical bearings (e.g., pins), tapered roller bearings, needle roller bearings, spherical roller bearings, and any

CLAIMS

1. A system, comprising:

a rolling bearing element assembly configured to enable oscillatory motion of a rotary element about a bearing system axis of the rolling bearing element assembly, wherein the rolling bearing element assembly comprises an inner race, an outer race, a contact surface of the inner race or of the outer race, a plurality of rolling bearing elements disposed between the inner and outer races, and a bearing cage configured to hold the rolling bearing elements such that the rolling bearing elements are circumferentially spaced about the bearing system axis; and

a spring-loaded indexing element fixed to the bearing cage and configured to enable rotation of the bearing cage about the bearing system axis via engagement of the spring-loaded indexing element with the contact surface, wherein the spring-loaded indexing element is configured to establish the engagement with the contact surface when the rotary element is rotating in a first direction about the bearing system axis, and wherein the spring-loaded indexing element is configured to slip along the contact surface when the rotary element rotates in a second direction about the bearing system axis opposite to the first direction.

2. The system of claim 1, wherein the rotary element is coupled to the inner race such that the rotary element imparts the oscillatory motion to the inner race, and wherein the inner race comprises the contact surface.

3. The system of claim 1, wherein the rotary element is coupled to the outer race such that the rotary element imparts the oscillatory motion to the outer race, and wherein the outer race comprises the contact surface.

4. The system of claim 1, wherein the indexing element and the contact surface are configured such that a frictional force between the indexing element and the contact surface holds the indexing element and the contact surface in engagement.

5. The system of claim 1, wherein the contact surface comprises ratchet teeth.

6. The system of claim 1, wherein the indexing element comprises a leading edge rotatably coupled to the bearing cage and a trailing edge configured to engage the contact surface when the rotary element is rotating in the first direction.

7. The system of claim 1, wherein the rolling bearing element assembly comprises a sealed rolling bearing element assembly.

8. A bearing system, comprising:

an outer race disposed in alignment with a bearing system axis;

an inner race concentric with the outer race and having an outer diameter less than an inner diameter of the outer race;

a rotary element coupled to one of the inner race or the outer race;

a plurality of rolling bearing elements disposed between and in rolling contact with the inner race and the outer race;

a bearing cage coupled to the plurality of rolling bearing elements, wherein the bearing cage is configured to keep the plurality of rolling bearing elements circumferentially spaced about the bearing system axis;

a spring loaded indexing element with a first end rotatably coupled to the bearing cage and a second end in contact with a contact surface of the inner race or the outer race;

wherein the indexing element is configured to engage the contact surface via the second end to enable rotation of the bearing cage in a first direction about the bearing system axis when the rotary element is rotating in the first direction, and wherein the second end of the indexing element is configured to slide along the contact surface to resist rotation of the bearing cage in a second direction about the bearing system axis opposite to the first direction when the rotary element is rotating in the second direction.

9. The bearing system of claim 8, wherein a frictional force between the second end of the indexing element and the contact surface causes the second end of the indexing element to engage with the contact surface when the rotary element is rotating in the first direction, thereby causing the rotation of the bearing cage and the plurality of rolling bearing elements in the first direction.

10. The bearing system of claim 8, wherein the contact surface comprises ratchet teeth, and wherein the indexing element is spring-loaded to interlock with the teeth when the rotary element is rotating in the first direction, thereby causing the rotation of the bearing cage in the first direction.

11. The bearing system of claim 8, comprising a plurality of spring-loaded indexing elements each coupled to the bearing cage and disposed circumferentially about the bearing system axis.

12. The bearing system of claim 8, wherein the indexing element comprises an asymmetric shape wherein the first end comprises a rounded leading edge and the second end comprises a trailing edge configured to engage the inner race.

13. The bearing system of claim 8, wherein the rotary element is coupled to the inner race and wherein the inner race comprises the contact surface.

14. The bearing system of claim 8, wherein the rotary element is coupled to the outer race and wherein the outer race comprises the contact surface.

15. A method, comprising:

facilitating oscillatory rotation of a rotary element about a bearing system axis and relative to a stationary element via a rolling bearing element assembly, wherein the rolling bearing element assembly comprises an inner race coupled to the rotary element, an outer race coupled to the stationary element, and a plurality of rolling bearing elements disposed between the inner and outer races;

allowing the rolling bearing elements to revolve about the bearing system axis in a first direction when the rotary element rotates in the first direction about the bearing system axis; and

resisting revolution of the rolling bearing elements about the bearing system axis in a second direction when the rotary element rotates in the second direction about the bearing system axis.

16. The method of claim 15, wherein allowing the rolling bearing elements to revolve about the bearing system axis in the first direction comprises engaging a spring-loaded indexing element coupled to the rolling bearing elements with a contact surface of the inner race when the rotary element rotates in the first direction, and wherein preventing or resisting the rolling bearing elements from revolving in the second direction comprises sliding the contact surface of the inner race relative to the indexing element when the rotary element rotates in the second direction.

17. The method of claim 15, wherein allowing the rolling bearing elements to revolve about the bearing system axis in the first direction comprises engaging a spring-loaded indexing element coupled to the rolling bearing elements with a contact surface of the outer race when the rotary element rotates in the first direction, and wherein preventing or resisting the rolling bearing elements from revolving in the second direction comprises sliding the contact surface of the outer race relative to the indexing element when the rotary element rotates in the second direction.

18. The method of claim 15, comprising engaging the rolling bearing elements with the inner race when the rotary element rotates in the first direction, and allowing the rolling bearing elements to slide relative to the inner race when the rotary element rotates in the second direction.