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Abrasive Material Screw Conveyor Hanger Bearing Arrangement

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Abstract

This disclosure describes a hanger bearing arrangement for screw conveyors handling abrasive bulk materials. The design addresses premature wear and failure of intermediate support bearings, a common cause of conveyor downtime. It employs a non-contact, indirectly lubricated bearing system, optimized material selection, and a flushing mechanism to prevent abrasive ingress. Hanger spacing is determined by shaft deflection limits. An integrated sensing system monitors bearing condition, enabling proactive maintenance before catastrophic failure. This arrangement aims to extend service life and improve operational reliability in challenging abrasive environments without direct lubrication through the shaft.

1. Technical Field

[0001] The present disclosure relates to screw conveyors, specifically to the design and operation of intermediate hanger bearing arrangements for conveying abrasive bulk materials.

2. Technical Context

[0002] Screw conveyors are widely utilized for transporting bulk materials. In applications involving abrasive materials, the intermediate hanger bearings that support the rotating screw shaft (10) are subjected to significant wear due from particulate ingress, leading to premature failure. Conventional designs often rely on direct contact bearings lubricated through the shaft or by grease fittings, which are vulnerable to abrasive contamination. The failure of these bearings frequently results in unscheduled downtime, increased maintenance costs, and reduced operational efficiency. A primary challenge is to develop a hanger bearing arrangement that can withstand prolonged exposure to abrasive environments, minimize wear, and provide adequate operational life without requiring through-shaft lubrication, while also offering a means to detect impending failure.

3. System Overview

[0003] The arrangement described here provides an enhanced hanger bearing system for screw conveyors operating in abrasive material environments. As shown in FIG. 1, the core of the system involves a screw shaft (10) supported by a hanger assembly (12) which incorporates a specialized bearing unit (14). This bearing unit (14) includes a bearing liner (24) that is designed for low friction and high wear resistance. A flushing system (16) continuously delivers a protective fluid to the bearing area, creating a positive pressure barrier to exclude abrasive particles. A monitoring system (18) is integrated to detect changes in bearing condition, such as increased temperature or vibration, and communicates these to a control system (20). The control system (20) can then trigger alarms or initiate shutdown procedures to prevent catastrophic failure. The overall design prioritizes indirect lubrication, material selection, and active protection against abrasives.

4. Components

[0004] The primary components of this hanger bearing arrangement include:

[0005]

- **Screw Shaft (10):** The main rotating element of the conveyor, typically fabricated from steel, which transports material. It includes a shaft journal (22) at each hanger location.
- **Hanger Frame (12):** A rigid structure, often made from steel or cast iron, that supports the bearing unit (14) and suspends it from the conveyor trough, allowing the screw shaft (10) to rotate freely. The hanger frame (12) is designed to minimize obstruction to material flow.
- **Bearing Unit (14):** This comprises the bearing housing (14) and the bearing liner (24).
- **Bearing Housing (14):** A robust enclosure, typically cast from a high-strength alloy or fabricated from steel, which holds the bearing liner (24) and provides mounting points for the flushing manifold (26) and sensor elements.
- **Bearing Liner (24):** A cylindrical or segmented insert that directly interfaces with the shaft journal (22). This liner is a key wear component. Materials are selected for their tribological properties under abrasive conditions, such as ultra-high molecular weight polyethylene (UHMW-PE), specific grades of polyoxymethylene (POM), or advanced ceramic composites. The liner (24) is designed to be easily replaceable.
- **Flushing System (16):** This system provides a constant flow of fluid to the bearing interface.
- **Flushing Manifold (26):** (See FIG. 2) A series of nozzles or channels integrated into or adjacent to the bearing housing (14) that direct the flushing fluid.
- **Fluid Supply Unit (28):** (Not shown in figures) Includes a pump, reservoir, filter, and pressure regulation components to deliver the flushing fluid. The fluid can be air, water, or a dilute non-abrasive slurry, depending on the conveyed material and operating environment.
- **Monitoring System (18):**
- **Temperature Sensor (30):** (Not shown in figures) An embedded thermistor or thermocouple located within the bearing housing (14) or near the bearing liner (24) to measure operating temperature.
- **Vibration Sensor (32):** (Not shown in figures) An accelerometer attached to the bearing housing (14) to detect abnormal vibration patterns.
- **Proximity Sensor (34):** (Not shown in figures) A non-contact sensor that monitors the radial clearance between the shaft journal (22) and the bearing liner (24), indicating liner wear.
- **Control System (20):** (Not shown in figures) A programmable logic controller (PLC) or similar industrial controller that receives data from the monitoring system (18), processes it, and provides operational commands or alarms.
- **Shaft Seal (36):** (Not shown in figures) A labyrinth seal or similar non-contact seal arrangement at the ends of the bearing housing (14) to further impede abrasive ingress while allowing flushing fluid egress.

5. Operation

[0006] The operation of the hanger bearing arrangement follows a defined sequence:

[0007] **Start-up:** Upon initiation, the control system (20) first activates the fluid supply unit (28) of the flushing system (16). Flushing fluid begins to flow through the flushing manifold (26) into the bearing unit (14), establishing a positive pressure zone around the shaft journal (22). This creates an initial barrier against potential abrasive ingress before the screw conveyor begins rotation. Once flushing pressure is confirmed by a pressure switch (not shown), the control system (20) allows the main drive motor to engage, initiating rotation of the screw shaft (10). Concurrently, the monitoring system (18) initializes, beginning data acquisition from the temperature sensor (30), vibration sensor (32), and proximity sensor (34).

[0008] **Steady Running:** During continuous operation, the screw shaft (10) rotates within the bearing liner (24) of the bearing unit (14). The flushing system (16) maintains a continuous flow of fluid, typically at a pressure ranging from 0.05 to 0.2 bar above ambient, creating a dynamic barrier that forces abrasive particles away from the critical bearing interface. The flushing fluid, after passing through the bearing clearance, exits through controlled egress points, carrying away any fine particles that might have bypassed initial exclusion. The monitoring system (18) continuously acquires real-time data on bearing temperature, vibration, and radial clearance. This data is transmitted to the control system (20) for analysis.

[0009] **Fault or Interruption:** If the monitoring system (18) detects abnormal conditions, such as:

[0010]

- **Increased Temperature:** A sustained rise in bearing temperature above a predetermined threshold (e.g., 50°C above ambient).
- **Elevated Vibration:** Vibration levels exceeding a pre-set root mean square (RMS) amplitude or exhibiting specific frequency characteristics indicative of wear.
- **Reduced Clearance:** The radial clearance measured by the proximity sensor (34) decreasing to a specified minimum, indicating significant wear of the bearing liner (24).

[0011] The control system (20) will trigger an alarm, alerting operators to a potential issue. Depending on the severity and trend of the detected abnormality, the control system (20) may automatically reduce conveyor speed, initiate a controlled shutdown, or recommend immediate inspection and maintenance. For instance, a rapid temperature increase combined with elevated vibration might trigger an immediate emergency stop to prevent seizure and damage to the screw shaft (10) or associated drive components. In the event of a flushing system (16) malfunction, such as a loss of fluid pressure, the control system (20) will also generate an alarm and may initiate a controlled shutdown to prevent operation without abrasive protection.

6. Example Embodiments

[0012] **Embodiment 1:** This embodiment utilizes a segmented bearing liner (24) made from a high-density UHMW-PE material. The liner segments are designed with a tongue-and-groove interface to minimize gaps and are secured within the bearing housing (14) by mechanical fasteners that allow for thermal expansion. The flushing system (16) employs compressed air as the protective fluid, delivered through a manifold (26) with multiple radially directed nozzles. The air pressure is maintained at approximately 0.1 bar above the internal pressure of the conveyor trough. A single temperature sensor (30) and a vibration sensor (32) are integrated into the bearing housing (14). Hanger spacing is calculated to limit static shaft deflection to 0.5 mm over the span.

[0013] **Embodiment 2:** In this configuration, the bearing liner (24) is a self-lubricating ceramic composite material, formed as a continuous sleeve pressed into the bearing housing (14). The flushing system (16) uses a filtered, recirculated water supply, with the flushing manifold (26) designed for laminar flow around the shaft journal (22). The water exits through an overflow weir, carrying fines to a settling tank for filtration before recirculation. This embodiment includes two proximity sensors (34) positioned 90 degrees apart to provide a more comprehensive assessment of radial wear, along with a temperature sensor (30) and a triaxial vibration sensor (32). Hanger spacing is designed to limit dynamic shaft deflection to 0.3 mm.

[0014] **Embodiment 3:** This embodiment features a bearing liner (24) constructed from a specific grade of polyoxymethylene (POM) with embedded solid lubricants. The liner is split for ease of replacement and features an interference fit with the shaft journal (22) under normal operating conditions. The flushing system (16) utilizes a dilute, non-abrasive slurry of fine, inert powder suspended in a carrier fluid. This slurry creates a sacrificial, low-shear layer between the shaft and the liner. The monitoring system (18) incorporates an acoustic sensor (not shown) alongside a temperature sensor (30) to detect early-stage wear and spalling through characteristic sound signatures. Hanger spacing is determined by the critical speed of the screw shaft (10), ensuring operation below 70% of the first critical speed.

7. Alternative Configurations

[0015] Several alternative configurations can be employed. The bearing liner (24) material could be a fiber-reinforced polymer, a bronze alloy with graphite inserts, or a silicon carbide ceramic. The flushing fluid could be an inert gas such as nitrogen, or a low-viscosity, non-toxic oil. The flushing manifold (26) design could incorporate tangential entry ports to induce a swirl flow, further enhancing abrasive exclusion. Instead of discrete sensors, a continuous acoustic emission monitoring system could be used to detect changes in friction and wear. The hanger frame (12) itself could be fabricated from a composite material to reduce mass and dampen vibrations. For specific applications, a sacrificial sleeve could be installed on the shaft journal (22) to serve as a wear surface, protecting the primary screw shaft (10) from abrasion.

8. Parameter Variations

Parameter	Range	Effect of Moving Within Range
Shaft Diameter	100 mm to 500 mm	Larger diameters increase shaft stiffness, reducing deflection and allowing wider hanger spacing. However, they also increase mass and rotational inertia, requiring more drive power and potentially larger bearings.
Hanger Spacing	1.5 m to 4.5 m	Reduced spacing limits shaft deflection, decreasing stress on bearings and potentially extending bearing life. Conversely, closer spacing increases the number of hanger bearings required, adding complexity, cost, and potential obstructions to material flow. Increased spacing requires a stiffer shaft.
Flushing Pressure	0.05 bar to 0.5 bar above ambient	Higher pressure provides a more robust barrier against abrasive ingress but consumes more flushing fluid or energy. Insufficient pressure may allow

Parameter	Range	Effect of Moving Within Range
		abrasives to enter the bearing interface. Optimal pressure depends on the particle size and density of the conveyed material.
Flushing Fluid Flow Rate	0.1 L/min to 5.0 L/min per bearing	Increased flow rate enhances cooling and abrasive removal but necessitates larger pumping capacity and fluid management infrastructure. Lower flow rates conserve resources but may compromise the effectiveness of the abrasive barrier, especially with high concentrations of fine particles.
Bearing Clearance	0.001 to 0.005 times shaft diameter	A smaller initial clearance can reduce shaft wobble and vibration but increases the risk of heat buildup and seizure if flushing is compromised or wear occurs rapidly. A larger initial clearance accommodates more wear before critical intervention but may lead to increased vibration and dynamic loading at the outset.
Conveyor Speed	10 rpm to 100 rpm	Higher speeds increase material throughput but also increase bearing surface velocity, potentially leading to faster wear if lubrication or flushing is inadequate. Lower speeds reduce wear rates but decrease throughput and may lead to material settling in the trough.
Abrasive Particle Size	50 µm to 5000 µm	Smaller particles are harder to exclude by flushing and can penetrate tighter clearances, potentially forming an abrasive paste. Larger particles may cause impact damage or become trapped, leading to localized wear or scoring. The flushing system design and pressure must be adapted to the typical particle size distribution.

9. Additional Implementations

[0017] The principles of this hanger bearing arrangement can be adapted for other industrial applications where rotating shafts operate in abrasive environments and require intermediate support. This includes, but is not limited to, rotary kilns, dryers, mixers, and certain types of processing equipment where direct lubrication is impractical or undesirable. The flushing system (16) can be modified to use the process fluid itself, provided it is non-abrasive and compatible with bearing materials, thereby reducing external fluid consumption. The monitoring system (18) can be expanded to include artificial intelligence (AI) or machine learning (ML) algorithms for predictive maintenance, analyzing sensor data trends to forecast bearing end-of-life with greater accuracy. Furthermore, the hanger assembly (12) can be designed with a quick-release mechanism to facilitate rapid replacement of the bearing unit (14), minimizing downtime during maintenance. The bearing liner (24) could also be designed with internal helical grooves to actively pump flushing fluid through the bearing interface, enhancing both lubrication and abrasive exclusion.

10. Figures

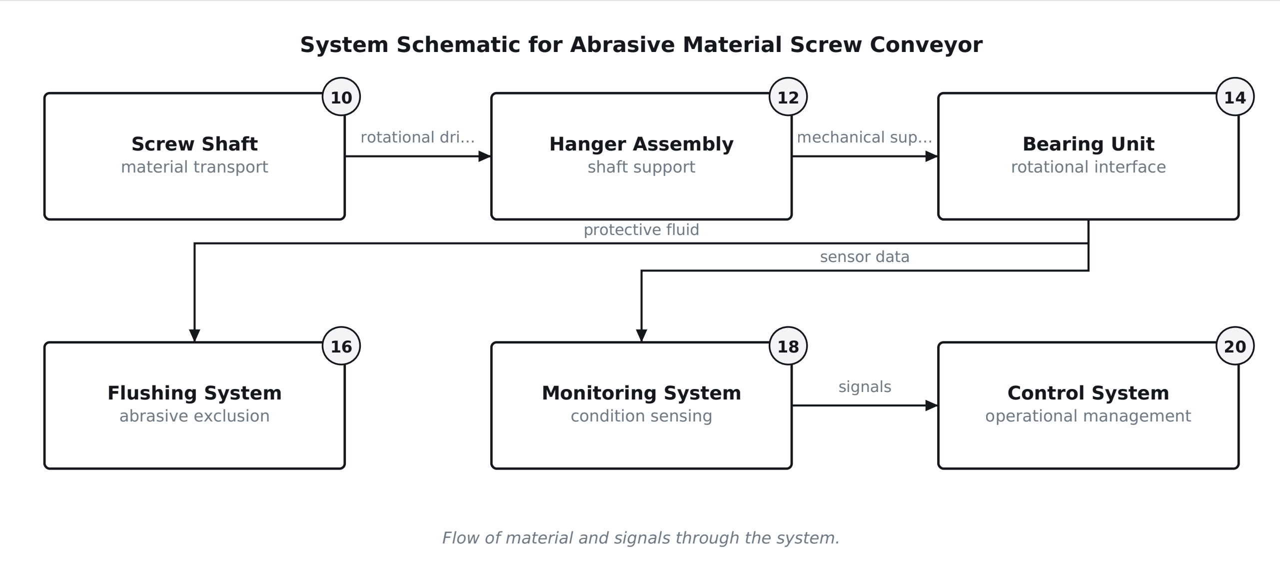

FIG. 1 A block diagram illustrating the primary functional components and their interconnections within the screw conveyor system. PNG

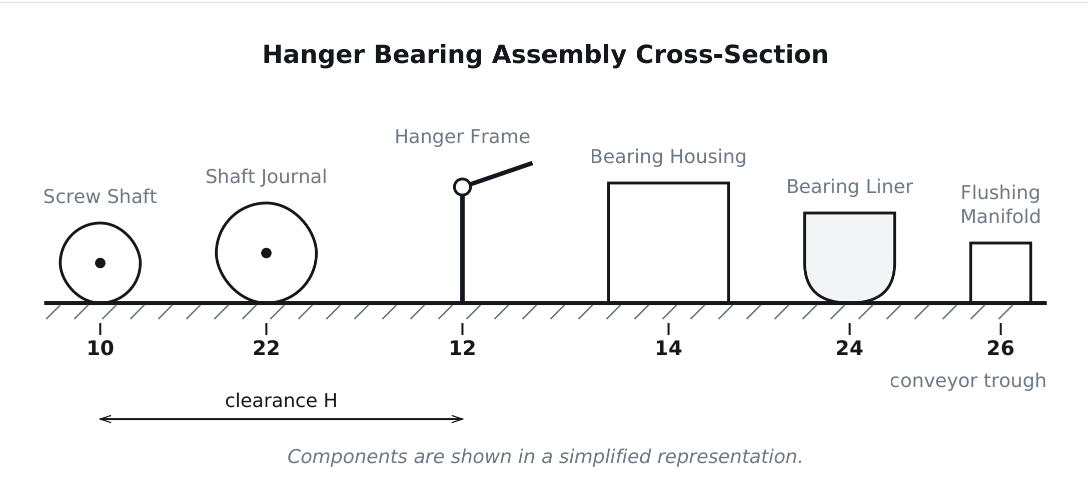

FIG. 2 An elevation view of the hanger bearing arrangement showing key components and their relative positions. PNG

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