WHITE PAPER

Optimizing Rotary Kiln Performance through Effective Trunnion Bearing Lubrication Protocols

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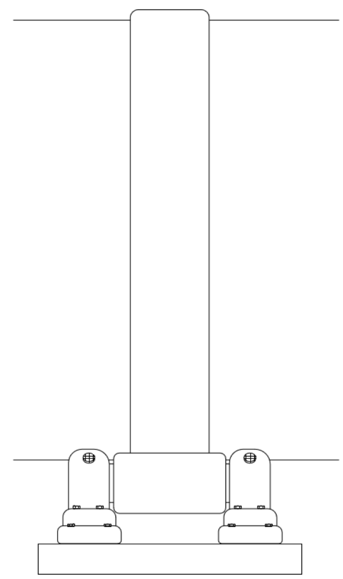
Introduction

In the realm of industrial rotary kilns, the lubrication of trunnion bearings plays a crucial role in optimizing operational efficiency and extending the service life of the equipment. Despite its importance, there is a noticeable gap in information on effective lubrication practices, which can result in inefficient performance and increased operational risks.



This white paper explores the challenges associated with rotary kiln lubrication, particularly focusing on managing operating temperatures under normal conditions and during the misalignment of trunnion bearings. The findings and recommendations presented herein aim to contribute to the advancement of best practices in rotary kiln operations, offering actionable solutions for lubrication and maintenance strategies that can improve thermal management, overall kiln performance and operational sustainability.

Literature Review of Journal Bearing Lubrication

The literature surrounding rotary kiln lubrication reveals a persistent gap between theoretical recommendations and practical applications, often resulting in suboptimal performance and premature equipment failures. Current studies underscore the critical role of effective lubrication in managing temperatures during normal operation and the challenging misalignment phases of trunnion bearings.

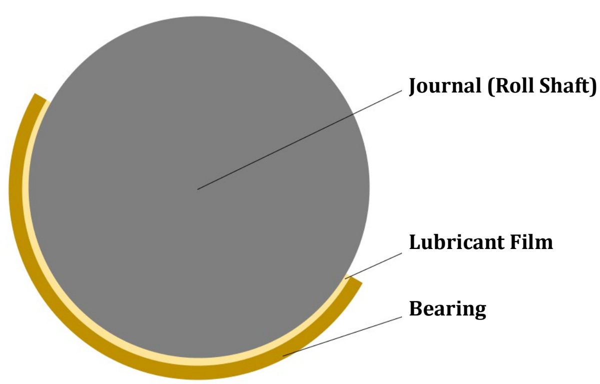


Figure A: *Components of the trunnion bearing that are relevant to the lubrication system.*

Historically, lubrication practices have emphasized viscosity requirements to maintain adequate film thickness and load-bearing capacity under varying operational conditions. However, research indicates a need for deeper exploration into the specific viscosity ranges and lubricant compositions that best mitigate frictional heat generation and wear in trunnion bearings.

Why is Viscosity Selection Important?

We frequently see companies using lubricants with unnecessarily high viscosities, a lubricant selection mistake that leads to equipment performance and longevity problems.

As depicted in **Figures B and C**, when the journal rotates within the bearing, the lubricant needs to flow upward toward the point experiencing the highest load in the system. **Figure B** illustrates the hydrodynamic lubricant film that fully separates the journal from the bearing, providing sufficient protection to reduce friction. Theoretically, a thicker lubricating film would provide greater protection. However, this assumption does not hold true in this scenario. **Figure C** shows that if the gravitational force exceeds the force pushing the lubricant, it will hinder the lubricant from flowing up the journal as required. If the lubricant's viscosity is too high, it won't spread adequately to prevent boundary lubrication in the necessary areas.

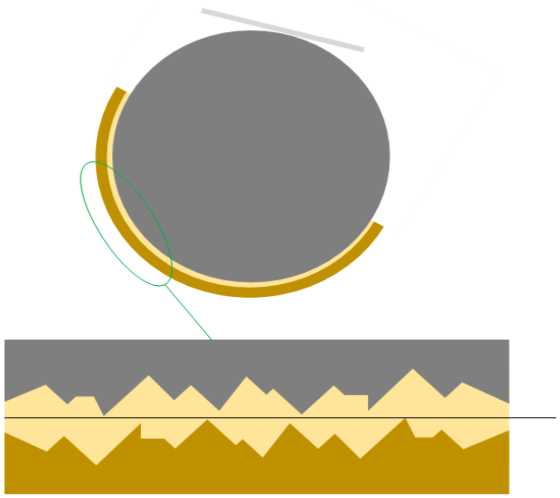


Figure B: *Journal and bearing in hydrodynamic state with adequate film strength.*

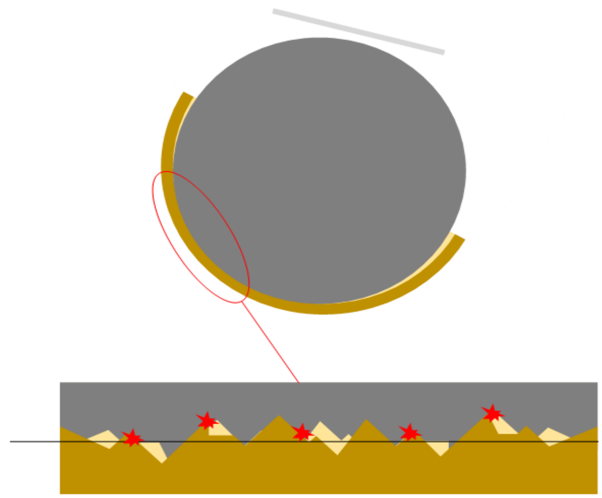


Figure C: *Journal and bearing in boundary state due to inadequate film strength.*

Example of a trunnion bearing that has experienced wear due to inadequate lubrication.
Source: *FL Smidth*

Viscosity Grade Recommendations

The following ISO viscosity grade lubricant recommendations are for journal bearings, considering factors such as load, surface speed, and operating temperature range.

Load	Surface Speed	RPM	Operating Temperature			
			20-50°C (68-122°F)	60°C (140°F)	75°C (167°F)	90°C (194°F)
High	-	~10	ISO VG 460	ISO VG 1,000	-	-
Moderate	-	50	-	-	Syn ISO VG 1,000	
Moderate	600-1,200 ft/min	400	ISO VG 100	ISO VG 150-220	-	-
Moderate		800	ISO VG 68	ISO VG 100	ISO VG 150	
Moderate	800-1,900 ft/min	1,200	ISO VG 46	ISO VG 68	ISO VG 100-150	
Moderate	1,200-2,900 ft/min	~1,800	ISO VG 32	ISO VG 46	ISO VG 68-100	ISO VG 150
Moderate	2,400-5,700 ft/min	~3,600	ISO VG 32	ISO VG 32-46	ISO VG 46-68	ISO VG 68-100
Moderate	9.4-22.6k ft/min	3,600	ISO VG 32	ISO VG 32		
Low (Tilt-Pad)	24-33k ft/min	~10,000	ISO VG 32	ISO VG 32	ISO VG 32	ISO VG 32-46

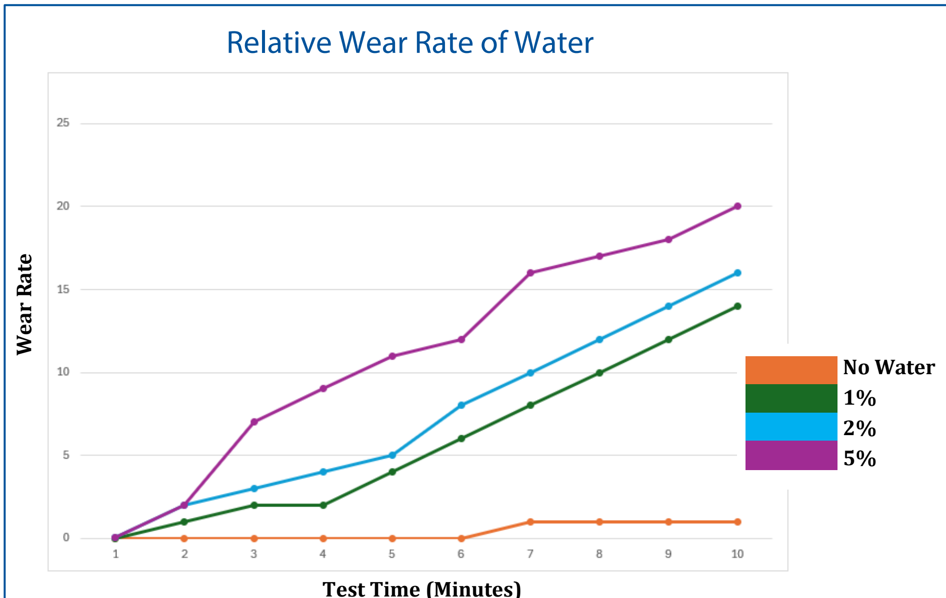
Source: LubeWorks Ltd.

ISO Cleanliness & Moisture Management

Adherence to ISO cleanliness standards emerges as a crucial factor in maintaining lubricant efficacy, particularly in environments prone to contamination from dust, particulates and processed byproducts. Contaminants can accelerate bearing wear and compromise overall equipment reliability, necessitating stringent cleanliness protocols in lubrication maintenance.

“Due to the more viscous hydrodynamic film of oil created in journal bearings, they are less susceptible to particle and water contamination than rolling element bearings. This does not mean that contaminated oil can be allowed to enter these bearings.” – The Practical Handbook of Machinery Lubrication, Fourth Addition.

As seen in the “Relative Wear Rate of Water” table, moisture is a very harmful form of contamination, making it crucial to remove it from the system. Moisture removal ensures efficient lubrication maintenance, minimizing wear and its harmful effects on equipment performance and longevity.



This chart demonstrates how moisture impacts lubricant performance over time.
***Source:** The Practical Handbook of Machinery Lubrication Fourth Addition, Section 12.*

We recommend using one of the following methods for accomplishing water removal:

1) Monitoring & Draining Oil with Shutdown
2) Converting to New Lubricant, Monitoring & Draining off Water without Shutdown

Method 1 – Monitoring & Draining Oil with Shutdown

The first method is to continue using your current lubricant and install LE's Xtract® Drain Port Adapter (LEX-DPADAPTOR) and Xtract® Oil Sight Glass & Level Monitor. While the primary function of this method is to monitor and drain the oil when it needs to be replaced due to moisture content, it offers additional benefits: viewing the oil condition and draining free water using the sight glass, collecting oil samples, and assisting with offline (kidney loop) filtration of the system (via optional quick connect and filtration unit). This method requires the equipment to be shut down during the draining or cleaning (filtering) process. The adapter, quick connect and sight glass are available in multiple sizes to accommodate your equipment; your LE consultant can assist you with making these selections.

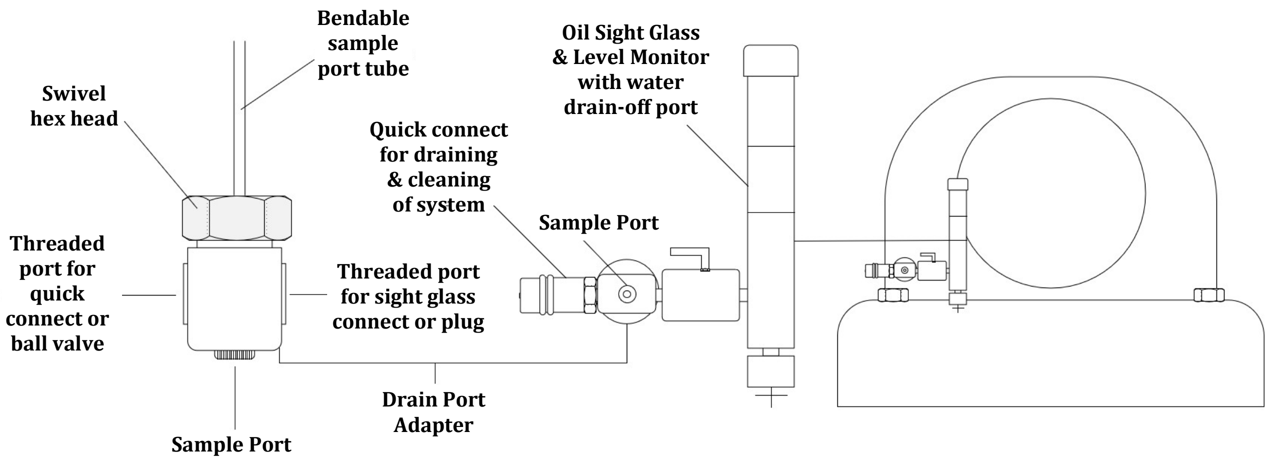


Figure D: *An Xtract Drain Port Adapter (drain port and oil sample port) and Xtract Oil Sight Glass & Level Monitor with drain-off port installed on a trunnion application. This setup allows the trunnion to be monitored by visual inspection (360-degree sight glass), and for the lubricant to be sampled, cleaned if needed using a filtration process, and drained of free moisture.*

Method 2 – Converting to New Lubricant, Monitoring & Draining off Water without Shutdown

The second method for removing water from the system involves converting the equipment to a high-performance synthetic lubricant with PAO (polyalphaolefin) base oil that facilitates natural separation of the lubricant from moisture within the system. PAO and mineral base oils are known to separate swiftly from water during operation, meaning water contamination can be periodically drained off the trunnion bearing. Using the same setup recommended for Method 1, any free water in the system can be drained off during production, with no shutdown required.

Benefits of Advanced Lubrication

Recent advancements in additive and base oil technologies offer promising avenues for enhancing lubricant performance in rotary kiln applications. These advanced formulations are designed to improve thermal stability, oxidation resistance and load-carrying capacity, thereby extending operational intervals and reducing maintenance downtime.

Additives

Monolec®, LE's proprietary wear-reducing additive, forms a single molecular lubricating film on metal surfaces, significantly enhancing film strength while maintaining clearances. As a liquid additive, it is not removed during filtration. When combined with synthetic PAO base oil, Monolec offers exceptional friction reduction and temperature protection. It is particularly notable for its impressive foam resistance, crucial in applications like trunnion bearings where avoiding foam is paramount due to elevated hydraulic pressure.

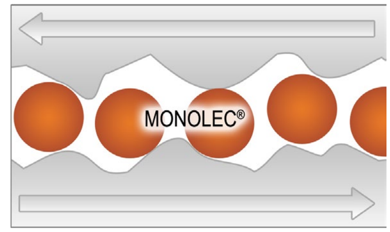


Figure E shows the detrimental effects of foam on trunnion bearing surfaces. Foam resistance within the lubrication film is crucial due to the possibility of foam formation leading to cavitation in both the journal and the bearing. This cavitation increases friction between the components as they move against each other, which in turn raises temperatures within the system. A lubricant with foam-resistance additive that effectively avoids foaming helps prevent these issues.

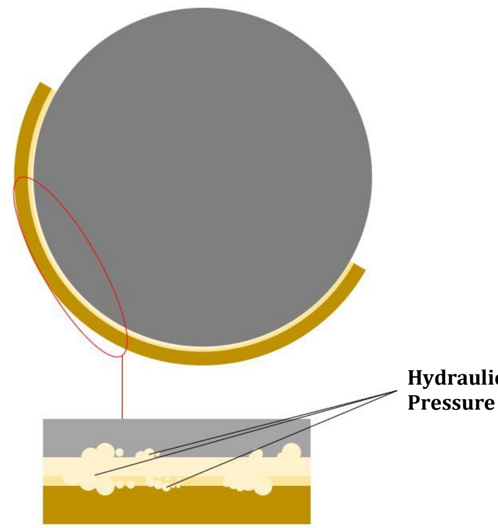


Figure E: *A foam-resistant lubricant is crucial in trunnion bearings, where elevated hydraulic pressure combined with foam can cause significant damage.*

Base Oils

In addition to the additive package, it is important that the correct base oil is used. The American Petroleum Institute (API) categorizes lubricants into several groups based on their base oil composition and refining methods.

These groups are commonly referred to as API base oil groups and are classified as follows:

- **Group I:** Produced by solvent refining processes, generally the least refined of all the groups and containing a higher level of impurities.
- **Group II:** Produced by hydro processing of crude oil, resulting in higher purity and better performance.
- **Group III:** High-quality base oils manufactured by further refining of Group II base oils through a more severe hydro processing/catalytic dewaxing process. These are superior to Group II, especially in oxidation stability and low-temperature properties.
- **Group IV:** Synthetic base oils, specifically polyalphaolefins (PAO), are synthesized through chemical reactions rather than refined from crude oil. They offer excellent stability at high temperatures and are widely used in high-performance applications.
- **Group V:** Includes all other base oils, including esters and polyalkylene glycols (PAG). These oils offer unique properties tailored to the needs of specialized applications.

Understanding the detrimental impact of moisture in trunnion bearings underscores the necessity of effectively separating moisture from lubricants to facilitate proper demulsification. To achieve this, base oils with excellent demulsibility, such as a PAO or high-quality mineral oils, are essential.

While PAG base oils excel in extreme high-temperature environments (exceeding 121°C (250°F), they exhibit poor water separation properties. They are designed instead for applications where water and oil must mix temporarily or where water contamination is unavoidable. This will limit their longevity in service as the moisture will compromise lubricity over time, leading to short lubricant lifespan or to equipment wear as shown previously in the "Relative Wear Rate of Water" table.

The better choice is using lubricants with PAO or mineral base oils, which will enhance moisture management by enabling swift and easy removal via sight glass. This mitigates moisture-related issues, bolsters lubricant protection, sustains lower operating temperatures, and reduces friction.

Lubricant Recommendation for Optimal Performance

For rotary kiln trunnion bearings, Lubrication Engineers recommends Monolec® Syn Industrial Oil, consisting of PAO synthetic base oil fortified with Monolec additive for increased film strength. This high-performance synthetic lubricant series, available in several different ISO viscosity grades, facilitates natural separation of the lubricant from moisture within the system. It demonstrates superior water separation compared to similar products on the market. Be sure to compare emulsion characteristics, as shown in the ASTM D1401 results on our product flyer, with the emulsion characteristics of any other lubricants being considered for use in your trunnion.

Using Monolec Syn Industrial Oil, our customers have experienced lower operating temperatures, reduced friction and wear, and increased efficiency and uptime. Together with the recommended drain adapter and sight glass, this approach ensures optimal performance and longevity of the equipment, while minimizing downtime and maintenance costs.

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