Understanding the Forces and Effects Causing Grease Migration – The Weissenberg Effect

Presented by David Beattie and Rhys Morgan, DASH Engineering
Bearing & Power Transmission World Meetings 2025

At the Bearing & Power Transmission World Meetings 2025, DASH Engineering delivered a presentation that challenged long-standing industry perceptions about bearing reliability. David Beattie and Rhys Morgan, both experienced specialists in bearing failure analysis, presented their findings on grease migration in labyrinth seals and revealed how the Weissenberg effect, a little-known scientific phenomenon, explains why traditional grease-filled labyrinths are inherently unreliable.

For more than 13 years, DASH Engineering has investigated over 1,000 conveyor pulley bearing failures, primarily in heavy industries such as mining, steel, and power generation. Their data consistently showed that contamination ingress through labyrinth seals, not misalignment, overload, or poor bearing quality, is the predominant cause of premature bearing failure.

The Problem with Grease-Filled Labyrinths

Labyrinth seals have been used in industry for over six decades, with widespread belief that they effectively protect bearings from contaminants. Conventional wisdom suggests that grease acts as a protective barrier, supported by the so-called three-barrier solution (sealed bearing, grease in the housing, and grease-filled labyrinth). However, DASH Engineering's inspections revealed a different reality. Bearings often showed severe water and dust contamination despite these measures. Instead of protecting against ingress, grease frequently stagnated inside housings and allowed contaminants to bypass the labyrinth.

Scientific Validation – The Wessenberg Effect

Recognizing that industry perceptions were misleading, DASH Engineering set out to **scientifically prove the mechanics behind grease migration.**
In 2017, engaged by Rio Tinto to address catastrophic failures in a 23 km conveyor system, the company built a dedicated test rig. Their experiments showed that grease does not consistently purge outward as expected. Instead, grease migrates inward toward the shaft, eventually carrying contamination directly into the bearing. This counterintuitive movement is explained by the **Weissenberg effect.**

Grease, being a non-Newtonian fluid with viscoelastic properties, behaves differently under rotational forces. Rather than being expelled by centrifugal force, it is drawn inward and can even climb along rotating surfaces. In practical terms, this means that grease-filled labyrinth seals are **pumping contaminants into the very components they are meant to protect.**

Engineered Solutions for Reliability

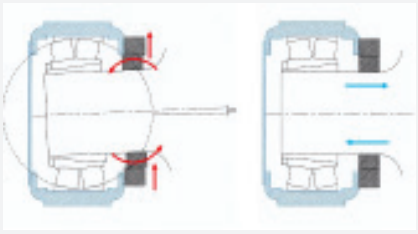
Armed with scientific proof, DASH Engineering shifted focus from identifying failure modes to designing engineered sealing solutions that overcome the limitations of grease-filled labyrinths.

- **The SAPO Seal –** Originally developed for Rio Tinto's conveyor pulley systems, the SAPO seal is a closed oil system designed to eliminate excuses for seal failure. It is maintainable, monitorable, and proven to drastically extend bearing life. To date, its implementation has saved Rio Tinto more than **AUD 7.8 million** in avoided bearing failures.
- **The G-Series Seal –** A more recent development, this version incorporates the same knowledge of grease migration but is optimized for compatibility with conventional lubrication systems. It provides a practical upgrade path for industries heavily reliant on grease-based maintenance practices.

Both solutions have been widely adopted across Australian mining operations, including iron ore and coal, with outstanding results in reliability and cost reduction.

— P1: Premature bearing failure from contamination ingress

— P 2: SAPO® Seal

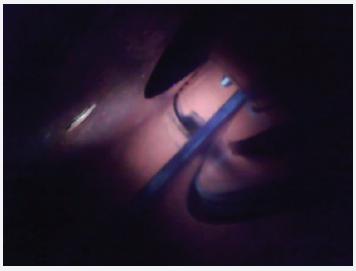


— P3: SAPO® Seal articulation and axial float

— P4: Before SAPO® Seals

— P5: After SAPO® Seals

— P6: Installation of critical pulley with SAPO® Seals



— P 7: Bearing housing endoscopic monitoring with the SAPO® Scope

— P8: SAPO® Seal in operation

Industry Impact

The implications of DASH Engineering's work are profound. By uncovering the true mechanism of grease migration and addressing it with innovative sealing designs, they have not only extended bearing life but also reduced downtime, improved safety, and delivered millions in savings to their clients.

Their findings also highlight a critical industry lesson: **long-held maintenance practices must be continuously challenged with scientific investigation and real-world data.** Myths and assumptions, left unchecked, can perpetuate costly inefficiencies.

Conclusion

The presentation at the Bearing & Power Transmission World Meetings 2025 made one fact clear: grease-filled labyrinth seals, despite decades of use, are fundamentally flawed as a sealing solution in harsh environments. Thanks to the pioneering work of DASH Engineering, industries now have proven alternatives that address the root cause of contamination ingress.

By combining rigorous failure analysis, practical field experience, and advanced engineering design, DASH Engineering has redefined best practice in bearing reliability—turning scientific insight into tangible industry solutions.

In summary, DASH Engineering's presentation underscores that grease-filled labyrinth seals, long regarded as standard in heavy industries, are not reliable barriers against contamination. Through more than 1,000 inspections and controlled experiments, the company demonstrated that grease migration draws contaminants inward rather than expelling them outward, directly causing premature bearing failures. By disproving the myth of the "three barrier solution" and introducing engineered sealing technologies such as the SAPO seal, DASH Engineering has provided industries with more robust, monitorable, and maintainable solutions. The results speak for themselves: improved reliability, significant cost savings, and enhanced safety across critical operations in mining and other demanding sectors.

David Beattie, DASH Engineering

Rhys Morgan, DASH Engineering