EXPERIMENTAL ANALYSIS OF RECIRCULATING LUBRICATION AND OIL BATH LUBRICATION ON TAPERED ROLLER BEARINGS

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Introduction

- Powertrains consist of multiple-precision components → these determine the global performance, reliability and durability of the entire machine. tapered roller bearings (TRB's) are a critical rolling bearing in this system, particularly in terms of efficiency and power losses.
- Inadequate lubrication causes TRB's failure. Sufficient amount of lubricant must be supplied in order to establish non-starved EHL conditions in the contacts. Optimal lubrication is required to reduce power losses in TRB's.

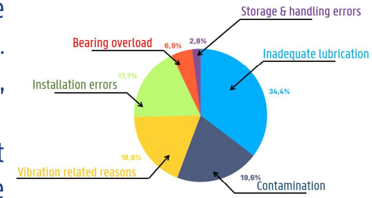


Fig 1: Why do TRB's fail? [1]

Purpose

- To provide improved recommendations for selecting an adequate lubrication method for TRB's, detailed measurements of global frictional torque and temperature distribution in TRB's are performed as function of different speed and loads. Moreover, different lubrication methods are investigated, considering different oil quantities in the bearing housing.
- The experimental data is compared with two existing frictional models, i.e., Harris [2] and SKF models [3], and their range of applicability is also assessed.

Methodology

- In this work an in-house bearing test setup (Fig 2) is used to simulate different operating conditions (speed and load).

Fig 2: Test Setup

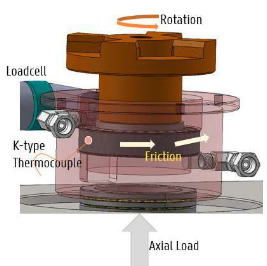
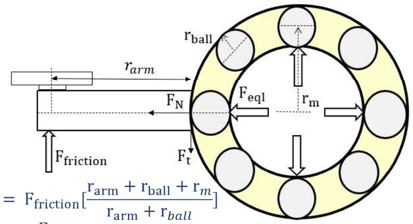


Fig 3: Frictional Force

- The bearing temperature is measured using thermocouple mounted on an outer stationary raceway, whereas the friction force is measured by a load cell (Fig 3) & schematic representation of the acting forces on TRB's shown in (Fig 4).



$$F_t = F_{friction}\left[\frac{r_{arm} + r_{ball} + r_m}{r_{arm} + r_{ball}}\right]$$

$$COF = \frac{F_t}{F_N}$$

Fig 4: Schematic representation of the acting forces

Results and discussion

- In theory, oil-jet lubrication results lower bearing frictional torque compared to forced oil circulation lubrication (Fig 5).

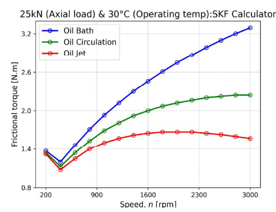


Fig 5: Lubrication modes comparison

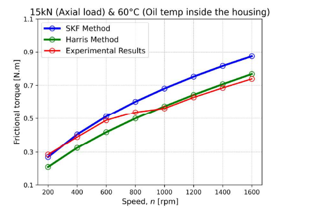


Fig 6: Models comparison with experimental data

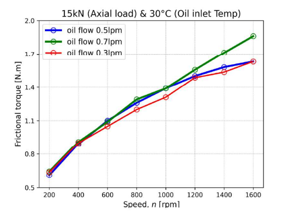


Fig 7: Forced oil circulation

- TRB's frictional torque (Fig 6) :SKF -> accurate for low speeds up to 600rpm. Harris -> more appropriate for higher speeds > 1000rpm [4].
- Oil flow rate has a significant impact on the frictional torque -> for 0.3 and 0.5 lpm oil at 1200 to 1600 rpm have almost equal frictional torque (Fig 7). Furthermore, increasing flow rate also increases the frictional torque by 12% at 1600rpm [5].

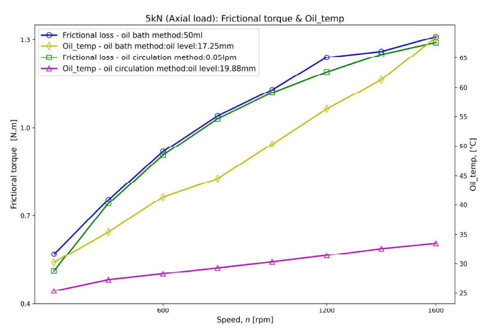


Fig 8: Lubrication modes comparison

- Zone 1 (0-600 rpm), forced oil circulation lubrication is required during the start of rotation as the oil bath can cause more churning & due to lower oil temp -> oil's viscosity is too high, in the beginning. For zone 2 (600-1200rpm), oil circulation yields 1% lesser frictional torque (Fig 8).

For zone 3 (1200-1600rpm), it is interesting to note that -> due higher oil temperature, lower oil's viscosity -> dimensionless film parameter λ is 1.1 -> partial or mixed lubrication established between contacts-> hence a higher friction torque is observed.

Conclusions:

- The experimental studies aim to examine the influence of lubrication modes on frictional torque. Based on the limited experiments, it can be concluded that TRB's have lower frictional torque when using circulating oil lubrication compared to the bath lubrication for medium size loads and speed.
- Based on experiments, optimal oil flow rate for medium size loads and speed application is 0.05lpm to establish non-starved lubrication and lower frictional torque.

References

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3. SKF Bearings" https://www.skf.com/"
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Acknowledgements

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