7th World Tribology Congress, WTC 2022
July 10-15, 2022, Lyon, France

Investigation into the Influence of Transverse Oscillations on the Performance of Rolling-Sliding Contacts

David Uribe[1)*], Armando Félix Quiñonez[2)] and Amir Kadiric[1)]

[1)]Tribology Group, Imperial College London, United Kingdom
[2)]SKF Research and Technology Development, Houten, The Netherlands
*Corresponding author: d.uribe19@imperial.ac.uk

Machine elements such as rolling element bearings are often subjected to external vibrations which can cause transverse oscillations in the EHL contacts these components rely on for their reliable operation. The effect of such transverse oscillations on damage potential and oil film thickness in EHL contacts is poorly understood. This work employs a custom-made set-up employing a triple disc contact fatigue rig, a powerful electrodynamic shaker and oil film monitoring using a capacitance method to investigate the effect of such oscillations on contact performance.

Keywords: rolling bearings, EHL, axial vibrations, rolling contact fatigue

1. Introduction

Rolling element bearings (REB) are often subjected to external dynamic loads during their operation. These loads can cause axial oscillations in a bearing. Such oscillations are suspected to adversely affect the performance of the rolling element – ring contact in terms of EHL film thickness and the resulting surface damage potential. However, there is very limited relevant experimental data on the topic leading to the lack of understanding of mechanisms involved which in turn hinders the introduction of any potential mitigating measures. Previous bearing tests provided some evidence that externally imposed axial vibrations could lead to premature surface damage [1]. However, more recent numerical studies of an EHL contact indicate that high-frequency small-amplitude transverse vibrations in an EHL contact have a very limited effect on fluid film thickness [2,3]. The present study aims to clarify the influence of transverse oscillations on EHL contacts pertinent to rolling bearing operation in terms of damage potential, film thickness changes and contact friction.

2. Methodology

The experiments were carried out using a triple-disc fatigue rig (PCS MPR) which has been heavily modified to allow for introduction of transverse oscillations across roller-ring contact and an indication of oil film thickness throughout the test. The set-up allows for close control of entrainment speed, normal load, oil sump temperature and slide-roll ratio. The film thickness is monitored throughout the test using a capacitance method.

The transverse vibrations are imposed by means of an electrodynamic shaker delivering 1,000 N peak force. The set-up allows for imposition of variable amplitude and frequency transverse oscillations independently of the rolling-sliding speed. Stroke and frequency ranges cover the range that may be expected in practical bearing situations; for example, at a frequency of 400Hz, the system can still deliver a 100 microns stroke. This means it is possible to study situations where the transverse speed is high in relation to rolling speed i.e. the contact can move a significant distance transversely in relation to the imposed contact width during a single overrolling cycle (Figure 2b), a situation which may intuitively be expected to adversely affect EHL film and contact damage potential.

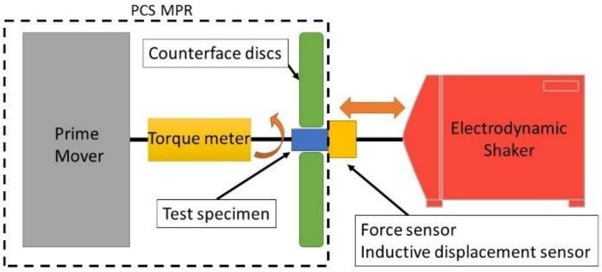

Figure 1: Transverse oscillations test rig layout.

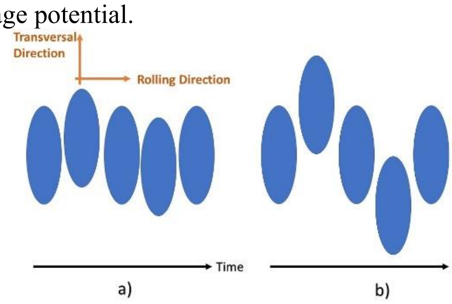

Figure 2: Instantaneous position of the elliptic contact during one transversal vibration cycle.

3. Results and Discussion

Results are presented to show the effect of transverse oscillations on surface damage with AISI 52100 roller specimens at different nominal lambda ratios, contact pressures and slide-roll ratios. A wide range of transverse stroke lengths and speeds, in relation to the contact width and speed in rolling direction, are studied. The results are discussed in relation to the effects on the EHL film thickness, on the friction observed in parallel on the same rig and on the resulting contact stress state.

4. References

[1] Nierlich, W. and Gegner, J., “Material Response Bearing Testing under Vibration Loading”, Bearing Steel, STP 1548, 2012, 329-340.

[2] Félix Quiñonez, A., “Numerical analysis of transverse reciprocating velocity effects in EHL point contacts”, Tribol Intl, 126, 2018, 1-8.

[3] Félix Quiñonez, A., “Analysis of wide EHL rolling contacts with small superimposed transverse speed oscillation”, Tribol Intl, 136, 2019, 207-215.