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Debris entrapment in elliptical EHD contacts

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This study focuses on debris entrapment occurring in ball bearings, especially within elliptical EHD contacts. Combining both numerical simulations and experimental work, allows to investigate and quantify the effect of several contact parameters on the phenomena leading to particle entrapment. Tests for different contacting materials (steel-steel vs steel-ceramic) as well as different ellipticity ratios enable to highlight the relative importance of each of these parameters.

Keywords: debris entrapment, hybrid bearings, elliptical contacts, numerical simulations, twin-disc test rig

1. Overview

Lubricating contacts is essential in a wide range of mechanical applications but warranty a safe and clean lubrication all along the bearing life has proved to be impossible to achieve. Debris entrapment inevitably occurs and thus has to be well understood in order to predict and limit premature failures. Although entrapment phenomena were already widely investigated in classical steel point contacts¹⁻³⁾, it is essential to quantify the influence on the entrapment phenomena by using different contacting materials, such as hybrid couple of materials, or different geometries (with different ellipticity radii).

In order to find and explain the influence of these parameters on particle entrapment, numerical simulations as well as experimental tests are performed. Respectively simulating particle trajectories upstream the contact area and revealing effective entrapment ratios on a twin-disc machine.

2. Numerical simulations

Numerical simulations focusing on the lubricant layer upstream the contact area (Fig.1), allow to simulate both the lubricant flow and the motion of suspended particle debris. Considering that particles are entrained by the lubricant flow and possibly, caught between the contacting surfaces, this numerical work allows to determine particle trajectories which highlight critical entrapment cases.

3. Twin disc experiments

Experiments are performed on a twin-disc machine⁴⁾. It is composed of two contacting discs a flat and a crowned one, supplied by a contaminated lubricant (Fig. 2). The nature and the geometry of the discs can vary so that several types of contact can be studied (Table 1).

Table 1 Operating conditions

Operating conditions	Pure rolling
Curvature radius of the crowned disc (mm)	17.5 – 35 – 70 – 200
Load (N)	600
Speed surface (m/s) / (rpm)	22 / 6000
Lubricant	Nycobase 5750
Viscosity at 60°C (Pa.s)	0.012

An observation of the contacting surfaces after the tests reveals dents which correspond to the marks generated by the particle entrapment. In this way effective entrapment ratios are obtained and quantitative comparisons can be performed.

4. Case study

The dual approach allows to validate numerical simulations with experimental tests and then to confirm the observed tendencies by performing a larger number of numerical calculations based on wider conditions.

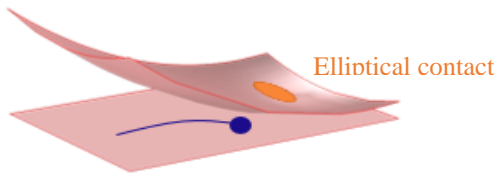


Fig.1 Numerical simulation upstream from the contact area

Hence the nature of the contacting materials was found to have a relative weak influence on the entrapment phenomenon. On the contrary the variation of the ellipticity ratio significantly affects the entrapment ratios. As well the independence of results by using different couple of materials as the ellipticity effect were first numerically assumed, they were then confirmed by the experimental work. Finally these tendencies were validated by a numerical analysis of the lubricant flow. It allowed to describe specific reverse flows occurring within elliptical contacts.

5. Conclusions

Bringing face to face experiments with numerical simulations led to focus on a key parameter governing the entrapment phenomenon in elliptical contact, which is the intensity of the reverse flow.

6. References

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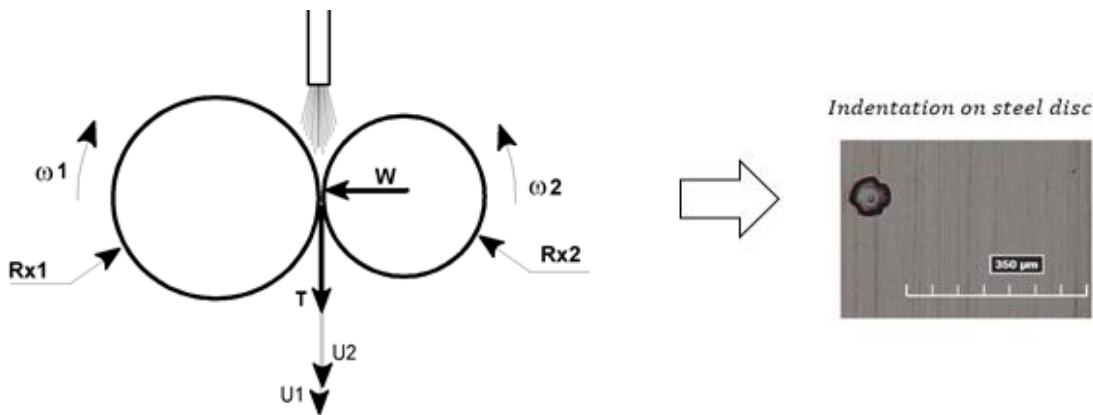


Fig.2 Twin-disc test rig (left) and indentation on the disc (right)