Textured Bearing Effect on Fluid Hydrodynamic Lubrication

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The friction between the inner parts of engines is responsible for a gas overconsumption of approximatively *3.4%* **[1]**. Hydrodynamic journal bearings played an important part in this loss. This work investigated the impact of textured shafts with low viscosity fluids on the hydrodynamic journal bearings using a dedicated workbench developed at the LTDS. Lower shear stress and film thickness were obtained for some peculiar pairs (dimple density of *5%* and a *0.9 μm* depth). The lubrication mechanisms were discussed: a coupling between viscous shear, thermal dissipation and local modification in the shear rate and pressure distribution was identified.

Keywords: hydrodynamic journal bearing, low viscosity lubricant, surface texturing, surface topography

1. Introduction

Surface texturing is known to modify local pressure distribution and the hydrodynamics behavior of journal bearings **[2]**. In this framework, the main goal of this work was to understand the lubrication mechanisms in journal bearing working with textured shafts and low viscosity lubricants using a hydrodynamics test rig developed at the LTDS.

2. Methods

2.1. Surface texturing

Texturing was performed on the shaft bearing spans. It consisted in cavity patterns realized with a femtosecond LASER at Manutech-USD. In this study, a focus was made on the density and the depth of these cavities: three different depths (from *0.5* to *2.5 μm)* and two dimples densities (*5%, 13%*) were tested and characterized with a Brüker interferometry profilometer.

2.2. Lubricants

From Group III base oil, simple mix between base oil and additives, to fully formulated oils, the low-viscosity oils (from *27* to *44 mPa.s* at *25°C*) were tested in order to separate the rheological and the chemical contributions.

2.3. Experimental device

A hydrodynamic test rig was developed based on the one used in **[2]**. This workbench, composed of two hydrodynamic journal bearing operating in oil bath with a *5 μm* clearance, was fully instrumented in order to monitor the fluid film behaviors in terms of film thickness, friction, position of the shaft and oil tank temperature for velocities up to *7000rpm* and controlled accelerations/decelerations.

2.4. Results

A velocity cycle was investigated: an increase up to *7000rpm*, a plateau at *7000rpm* followed by a decrease. In the smooth case, the shear stress first increased before decreasing during the velocity plateau (see *Fig. 1*) for an average film thickness of *5 μm* and a minimal film thickness of *3.6 μm*. In the textured case, the trend remained similar with lower or higher values of shear stress depending on the dimple density and the cavity depth, and thinner minimum film.

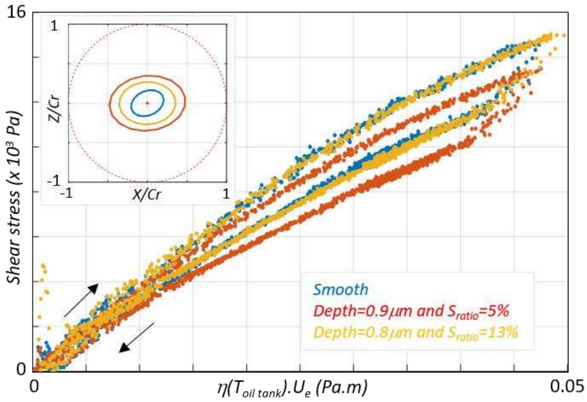

*Figure 1: Illustration of the shear stress evolution vs entrainment product, viscosity*velocity, for smooth and textured shafts (depth of 0.9 μm, dimple densities of 5% and 13%). The dimensionless shaft center position, corresponding to the film thickness distribution (clearance Cr of about 5 μm), was also indicated in the inset.*

3. Discussion

The shear stress measured with the smooth shaft was interpreted in terms of viscous friction and shear-induced thermal increase in the fluid film. A thermal regime was observed during the velocity increase and consecutive plateau although an athermal behavior was revealed during the velocity decrease. The introduction of a textured shaft showed that a friction decrease could be obtained (see *Fig. 1* for the *5%* dimple density) associated with a modification of the film thickness distribution. The mechanisms at stake were discussed, showing that the coupling between viscous shear, thermal dissipation and local change in shear rate and/or pressure distribution due to the presence of cavities, was responsible for the possible decrease in shear stress.

4. References

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