EXPERIMENTAL STUDY ON THE STRIBECK CURVE

Xiaobin Lu
Ph.D. Candidate

Faculty Advisor: Dr. Michael. M. Khonsari

INTRODUCTION

Stribeck (1902) carried out systematic experiments to show the existence of the minimum point proposed by Thurston (1885) and provided a clear view of the characteristic curve of the coefficient of friction versus speed. In recognition of his contribution, this curve is universally referred to as “the Stribeck curve” (Dowson, [1]). In some sense, especially after the speed parameter was extended to the Sommerfeld number ([2]), the Stribeck curve acquired a much greater breadth as its applicability extended to a far greater number of tribological components than merely journal bearings. It has been long recognized that the coefficient of friction is influenced by many parameters such as the material properties, the surface finish, the viscosity of the oil, and the operating conditions such as the speed and the pressure on the bearing. While many researchers illustrated the shift of the Stribeck curve under various conditions, none attempted to predict the transition point—the point that marks the watershed of the mixed and the hydrodynamic lubrication. This problem was tackled by Vogelpohl (1958) [3] who was probably the first researcher to have succeeded in developing an empirical equation to calculate the lift-off speed. We present the results of a series of experiments that were conducted to explore the behavior of the lift-off speed. Comparison with Vogelpohl’s equation is also presented.

EXPERIMENTAL

Figure 1 shows the schematic of the apparatus (Lewis LRI-8H) used for measuring the coefficient of friction of journal bearings.

Experiment procedure

The system is balanced so that the coefficient of friction is nil when the shaft is at static position. At each speed, the history of the coefficient of friction is monitored and recorded.
THEORETICAL PREDICTION OF THE LIFT-OFF SPEED

Theory development

When lift-off occurs, the speed $N_T$ satisfies the definition of the Sommerfeld number

$$S = \frac{\mu N_T}{60} \left( \frac{R_s}{C} \right)^2$$

So that

$$N_T = S \times \frac{P_L \left( \frac{C}{\mu} \right)^2}{R_s} \times 60$$

Khonsari & Booser (2001 [4]) obtained the following equation based on the numerical solution of Reynolds’ equation

$$S = \frac{h_{min}}{4.678C(L/D)^{0.044}}$$

The minimum film thickness can be calculated by the definition of $\Lambda$

$$h_{min} = \Lambda \times \left( R_s^2 + R_b^2 \right)^{\frac{1}{2}}$$

Combining those equations, the lift-off speed can be determined by

$$N_T = \frac{60P_L \Lambda \left( R_s^2 + R_b^2 \right)^{\frac{1}{2}}}{4.678C(L/D)^{0.044} \left( \frac{C}{\mu} \right)^2}$$

Comparison of theoretical prediction and experiment results

<table>
<thead>
<tr>
<th>Load (N)</th>
<th>Lift-off speed (rpm) Vogelpohl</th>
<th>Lift-off speed (rpm) Khonsari</th>
<th>Lift-off speed (rpm) Experiment</th>
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CONCLUSION

Increasing oil temperature and load shifts the lift-off speed to the right. In mixed or boundary lubrication regime, higher temperature creates bigger friction coefficient, while in the full-film lubrication regime, the opposite is true. Higher load causes smaller friction coefficient in the full-film lubrication regime. It is also shown that an equation derived based on the numerical solution of the finite Reynolds equation can effectively predict the lift off speed.

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REFERENCES