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Determination of lubrication regime of a real application through oil film thickness analysis based on the similitude of Hersey number

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Guaranteeing the correct lubrication is fundamental to ensure the safe operation and durability of mechanical components. In this paper, we present a methodology to determine the lubrication regime of a real system by measuring the oil film thickness on a laboratory scale. This innovative procedure is based on the similitude of Hersey number between the industrial and the laboratory case and it can be applied for a wide range of industrial applications considering the characteristic of mechanical components (geometry, operating conditions) and lubricant properties (viscosity and density).

Keywords: Tribological test, oil film thickness, hydrodynamic regime, methodology

1. Introduction

In this experimental work, the capability of lubricating oils to ensure the correct oil film thickness is studied. The procedure described, starting from the Stribeck curve, is based on the similitude of a key parameter that considers the core variables of the mechanical component (geometry and operating conditions) and the properties of the lubricant (kinematic viscosity and density) to qualitatively evaluate the lubrication condition. A case study is presented to validate the methodology.

2. Methods

The methodology is based on the similitude between real and a laboratory case of a key parameter (Hersey number - H). We started to calculate the H in eq. (1), by using the input data from a real case. Then, we identified the corresponding parameters for the laboratory machine, mainly load (P) and speed, to meet the same values of H calculated.

$$H = \frac{\eta v}{P} \tag{1}$$

Regarding the definition of P in eq.(1), we assumed:

- for the real case, it is considered equal to the load applied by the system divided by a unit length;
- for the lab scale, calculated as the load divided by the diameter of contact length using the EHD [1].

We built up the oil-film thickness curve and we focused on the point that corresponds to the rotational speed selected. After having determined the value of the oil-film thickness (h), we calculated the value of lambda (λ), parameter that identifies the lubrication regime. We divided h by the RMS (from Table 1) obtaining the desired λ: if it is greater than 3 (value that corresponds to 60 nm), we could define that oil was operating in hydrodynamic regime.

Table 1. Properties of the specimens.

		Specimens	
Parameters	**U.M.**	**Ball**	**Glass disc**
Surface roughness	[nm]	20	5

2.1. Results

The case study presented is a journal bearing for a steel roll forming machine. Calculated H was equal to 7.5×10^{-6}. The film thickness for all oils [2][3](Oil A and B) tested was higher than our threshold value. At all three operating temperatures and according to the methodology we were in the hydrodynamic regime (see Table 2).

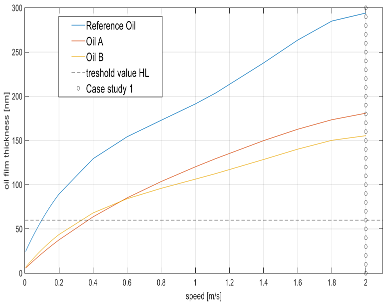

Figure 1. Results using 1N as load applied at 70°C.

Table 2. Oil film thickness at 1N load and 2m/s speed.

Temperature [°C]	Lubricants	40	70	100
Oil film thickness [nm]	Reference Oil	502	282	154
	Oil A	265	169	106
	Oil B	346	149	96

3. Discussion

In this paper, a cheap and versatile methodology is presented. It aims at determining the lubrication regime of a system by measuring the oil film thickness on a laboratory scale based on the similitude of Hersey number. The low viscosity candidates tested, compared to the reference oil, present lower oil film thickness (see Figure 1), but it is sufficient to ensure lubrication film and avoid the risk of contact and dry friction between the moving parts.

4. References

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