A SIMPLE METHOD TO TEST THE LUBRICANTS' ABILITY TO GENERATE LUBRICANT FILMS

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Abstract: *The primary role of the lubricant in mechanical pairs is to create a permanent thin film between the surfaces. A simple method to evaluate, in an orientative manner, the oil film generation ability of a fluid or a grease with a very little quantity of this lubricant is presented. These results show a correlation of the film thickness with the rolling speed and also with the support's rigidity.*

Keywords: *film thickness, lubricant.*

1. Introduction

The primary role of the lubricant in mechanical pairs is to create a permanent thin film between the surfaces.

From the first surface to the second one, through film thickness a gradient of the speed occurs. Dynamic interaction of the elements in the pairs is manifested by a load transmitted between surfaces. This load must not expulse the lubricant from the film. So, the permanent character of the film presence between surfaces, even at important variable loads, is essential for the pairs' better functionality.

The third property of the thin lubricant film from the mechanical pairs is to reduce the friction. Without lubricant the friction is higher because it is generally a metal on metal contact. With lubricant, the friction is an internal one, between the lubricant layers, being smaller than the metal-metal friction.

The ability of the lubricants to generate consistent film in mechanical pairs can be evaluated theoretically and also experimentally.

The theoretical methods offer different formulas to calculate the film thickness, [1], [2], [3], [4]. In these formulas, must be introduced the values of geometrical and kinematics parameters, dynamics parameters and also the physical properties of the lubricant such as viscosity and density and the correlations with pressure, temperature, shearing, and shearing speed.

The experimental methods involve tests of the oil on tribological devices and measuring of the film thickness in similar working conditions with the real pairs. These methods are expensive, because they involve a high level technical support and also a large quantity of lubricant for the test.

In literature, a test with some similar aspects was presented by Takamichi and Yasuhiro, [5], for the study of the film thickness in metal working.

A simple method to evaluate, in an orientative manner, the oil film generation ability of a fluid or a grease with a very little quantity of this lubricant is presented.

2. Principle of the method

The experimental method presented here is based on an accurate control of the mass of the lubricant used in the test and also on the measuring of the area of the generated film. Then, the film thickness will be calculated using also the density of the lubricant and the identity of the lubricant volume before the experiment and after it. Supposing that during the film generation, the oil located after the middle of the contact area will leave the contact only on the normal exit and that the lubricant films has approximately the same value, h, and could be calculated as the ratio between the lubricant mass, m, and the product between lubricant density, ρ and the area of the generated film, A:

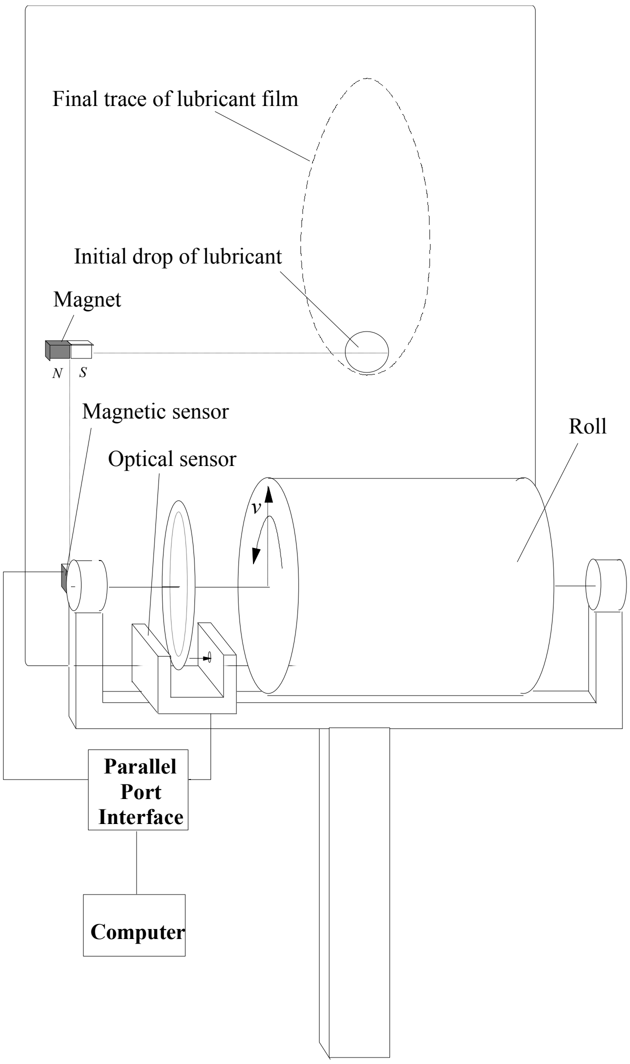

Figure 1: *Figure 1. The data acquisition system structure of the roll.*

$$h = \frac{m}{\rho A}. \quad (1)$$

3. Validation of the method

In order to validate this method, a simple test rig and an associate experiment were imagined. By this experiment, a lubricant film is generated using a controlled quantity of lubricant,—dropped on a thin plastic film, supported on a plane surface and a cylindrical roll is displaced over this, with a controlled speed in rolling motion. The value of the area of the generated lubricant film is evaluated by image analysis.

The test rig consists of a cylindrical roll, a system of rotational speed control with two sensors and data acquisition. The speed of the cylindrical roll, figure 1, was measured using a rotational optical speed control sensor.

A second magnetic type sensor is used to detect the moment of the roll's contact with the lubricant (the start of the formation of the film). This sensor is activated by a magnet present in the neighborhood, placed near the oil, lateral, perpendicular on the rolling motion direction, see figure 1.

These sensors are connected to a data acquisition system and a computer over the parallel port. A dedicated software assists the experiment and a graphical representation of the speed of the roll and a data file are generated. A marker is activated on the graphical representation for the speed value corresponding to the magnet presence near the corresponding sensor.

3. Experiments

A gears lubricant and a contact (steel roll on porous high deformable, and a steel roll on a 10 mm plexiglass layer, (both supported by a 36 mm plywood floor,) were used in the experiments.

For each experiment were done at least three tests for three different speeds of the roller. The experimental method supposes the step by step procedure:

1. Determining the mass of the plastic foil. This is used as the first surface in contact. An electronic balance with 0.001g precision was used.

2. Deposing two or three drops of the testing oil on the foil.
3. Determining the mass of the foil with lubricant. The difference between the two values of the oil mass is calculated.
4. Placing the foil on the support.
5. Positioning of the magnet laterally, near the lubricant.
6. Starting the data acquisition system and software.
7. Displacing the roll over the lubricant. A lubricant film is created by the lubricant in the gap between the roller and the foil.
8. Photographing the lubricant trace, adherent to the foil, with a reference object, with a determined area placed in the photographing area.
9. Mass determination of the foil with remaining adherent lubricant film. The adherent lubricant mass can be determined by subtracting from the initial mass of the lubricated foil, the mass of the foil with remaining adherent lubricant film.
10. Oil traces image analysis. This image analysis allows the evaluation of the area of the reference object image and of the adherent oil image. The ratio between reference object area and the referent object image area provides a constant scale that is used to calculate the effective area of the oiled trace.
11. Film thickness calculation.

4. Results and discussions

An example of the lubricant trace on the foil, after the roll's passing over the lubricant, is presented in figure 2.

To increase the contrast between the lubricant area and the outside area, before taking the photo, the trace area was covered by a thin layer of talc.

A study of the results dispersion due to the errors of the image area evaluation and reference object area evaluation were done, by taking a number of 5 photos of the same trace and independent areas' evaluation. The evaluation of the film thickness has errors of less than 1 percent.

The experimental results are presented in table 1 and figures 3.

Figure 2: *Example of the lubricant trace. Gears oil, roll steel/porous layer, v=3.4 m/s.*

Table 1. *Experimental film thickness values.*

dropped oil mass	oil trace mass	% from dropped mass	Roll speed	Film image area	Coin image area	Film area	Film thickness
Grams	Grams	%	m/s	mm^2	mm^2	mm^2	mm
steel/porous layer, reference object area 260.441 mm^2							
0.048	0.023	50.785	4.90	63144.190	11534.610	1425.739	0.036
0.059	0.030	49.663	3.93	48085.590	6591.820	1899.849	0.034
0.063	0.033	47.619	6.39	36419.790	3738.090	2537.448	0.027
steel/plexiglass, reference object area 423.826 mm^2							
0.077	0.018	23.503	6.70	10285.212	2970.849	1467.306	0.057
0.087	0.040	46.110	7.38	11479.608	3034.452	1603.374	0.059
0.111	0.054	48.736	8.80	8304.569	2060.540	1708.142	0.071

These results show a correlation of the film thickness with the rolling speed and also with the support's rigidity.

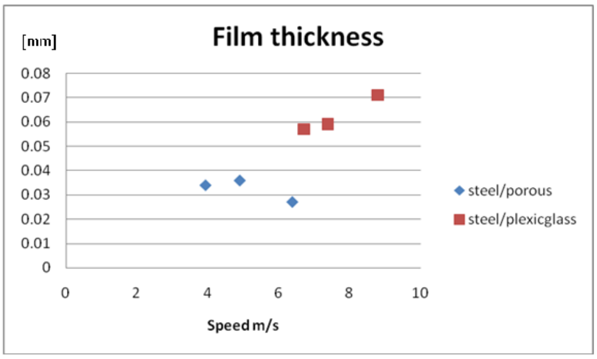

Figure 3: *Film thickness versus speed.*

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