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The Experimental Determination of the Oil Layer Thickness Variation from the Antifriction Bearings

The publication presents an experimental method for determining the thickness variation of the oil layer from the antifriction bearings of Diesel engines of large power during engine operation.

***Keywords**: method, thickness variation, antifriction, bearings, Diesel engines*

1. The method

The method of measurement is based on the fact that during the gudgeon's rotation in the field, between the gudgeon and the sleeve bearing a thin layer of oil is forming which isolates electrically the gudgeon from the sleeve bearing. In this way, the gudgeon and the sleeve bearing form an electric capacitor.

Starting from these observations, in order to measure the oil layer thickness from the bearing, in the inferior sleeve bearing there have been made two circular openings inside which where fixed two circular capsules(made from the same material as the sleeve bearing) with the help of a special isolating adhesive. These capsules are electrically isolated from the sleeve bearing. Through an appropriate technology the whole ensemble has subsequently been galvanic covered, aiming that the sliding surface of the sleeve bearing should be continuous, without inequalities in the mounting area of the capsules (fig. 1).

Each of the capsules has been designed with an exterior electric connection, isolated from the sleeve bearing, mounted through a channel on the sleeve bearing's exterior surface, and fixed with the same adhesive.

This way, between each capsule and gudgeon an electric capacitor has been built. Considering the small dimensions of the capsule reported to the radius of curvature of the sleeve bearing, but also the reduced thickness of the dielectric (lubrication oil) it can be considered as a flat capacitor. Between the capacitor's capacitance and the thickness of the oil layer we have the following relation:

$$C = \frac{\varepsilon_0 \cdot \varepsilon_r \cdot S}{g} \qquad (1)$$

Where:

C : the capacitor's capacitance [pF] ε_0 : the absolute void permittivity[0.0885 pF/cm] ε_r : the relative permittivity of the lubrication oil

S : the capsule's surface [cm²] g : the oil layer's thickness [cm]

From the formula (1) results that in order to determine the thickness of the oil layer from the bearing, the knowledge of two values: ε_r and C, the other ones being constant. For the resulted sleeve bearings the capsules have been circular with a 20mm diameter, si S=3.14 cm².

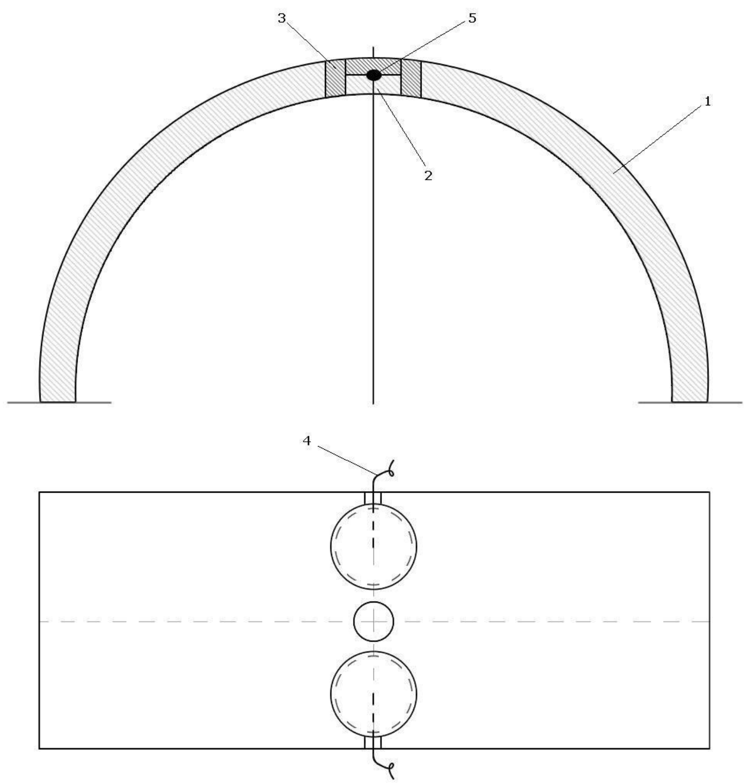

Figure 1

In figure 1 are represented with:

1. sleeve bearing, 2. pill, 3. electrical isolation adhesive , 4. electrical connection, 5. sticking (between poz. 2 and 4)

2. The determination of the relative permittivity ε_r for the lubrication oil

In order to determine the relative permittivity ε_r of the lubrication oil a measuring cell has been used, the determining method being the already known one. There have been made determinations of the permittivity ε_r with new oil, used oil and oil mixed with diesel fuel. The rate of the variation curves of ε_r with the temperature depending of the usage degree, is shown in the figure no.2:

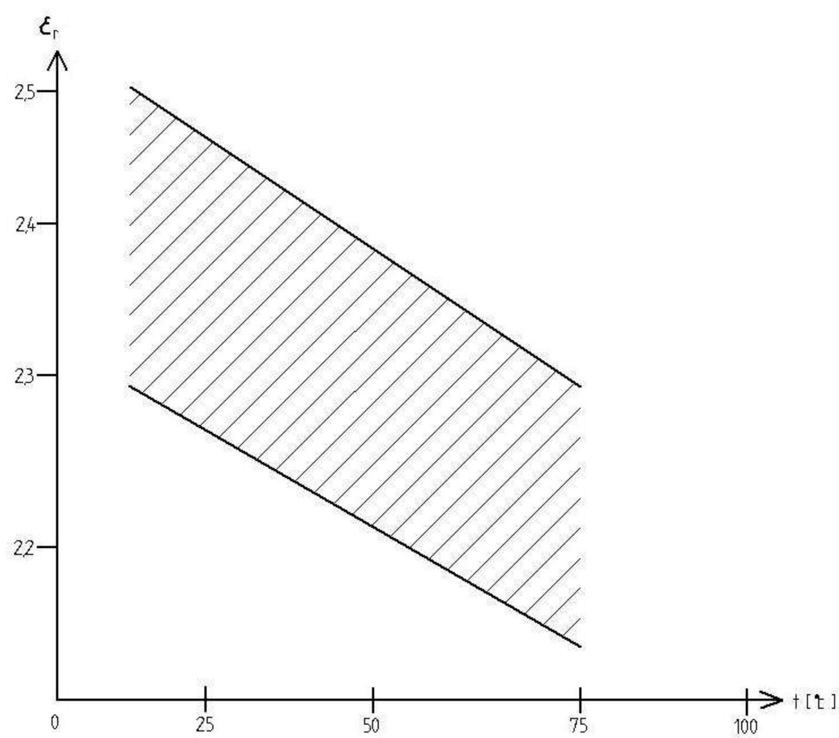

Fig . 2

In figure 2 are represented with: 1: clean oil (new) and 2: used oil (300 hours functioning time)

On the figure the variation range of ε_r depending on the oil quality and temperature has been highlighted. For a rapid determination of the oil layer's thickness there can be used values of ε_r depending on temperature and knowing the approximate usage degree of the oil, it can be vertically interpolated; for precise determinations some samples of oil that will be measured in the laboratory are needed.

3. Measuring the capacitance C

Because the oil film thickness is a time variable value the outcome is that the capacitance of the capsule's capacitor depending of the gudgeon is also a variable value.

For knowing anytime the film's thickness the recording of the C capacitance's time variation was necessary. The block scheme of the installation used for recording the time variation of the C capacitance is shown in the figure no.3:

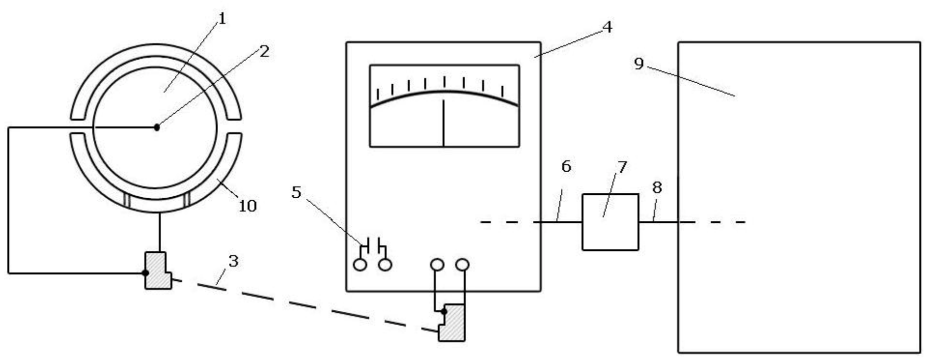

Figure 3

In figure 1 are represented with: 1: gudgeon, 2: axial contact, 3: screened cable 4: Bruel- Kjaer deviation bridge, 5: reference gauge capacitor, 6: bridge connection cable, 7: adaptor, 8: recorder connection cable (at the box corresponding the loop position), 9: recording oscillograph

The connection between the capsule from the sleeve bearing and the rest of the installation has been made with a screened cable, by tying the capsule at the central wire of the cable. The other armature of the capacitor, the sleeve bearing was connected to the cable's jacket through an axial brush like contact which has been done at the opposite end of the engine - generator clutch.

The ensemble obtained in this manner from the capsule's capacitance depending on the gudgeon and the joining cable's capacitance was tied to the output terminals of the comparison bridge (poz. No.4). At the reference terminals of the bridge a gauge master condenser has been connected. The bridge executes the comparison between the gauge's capacitance and herself, connected to the output terminals, offering as a result a continuous voltage signal pro rata with the declination of the measuring capacitance towards the gauge, and with the polarity corresponding to a negative or a positive declination. When the two capacitances are equal the signal is 0. This signal is applied to a recorder which holds the capacitance's variation. The comparison bridge offers the possibility of measuring a capacitance towards the gauge in the range $200\% Ce \div -65\% Ce$.

By properly choosing the gauge master capacitance, the bordering of the measured capacitance's variation within the functioning range of the device has been obtained. However, the high values of the capacitance (corresponding to very low values of the oil film thickness in the contact area) cannot be measured.

4. The interpretation of the results

In order to reveal the method used for interpreting the results, some specifications of the notations used are needed:

Cx : the capacitance recorded on the oscillogram (the one of the capsule-gudgeon ensemble with the cable's capacitance and the parasite one) [pF]

Cc : the capsule's capacitance (which is realized between the capsule and the gudgeon and interferes in the calculation of the oil layer thickness) [pF]

Cp : the parasite capacitance (of the cable and of the device) [pF]

d : the declination of the spot on the oscillogram corresponding to Cx variation (with the meaning established as in figure no. 4) [mm] k : coefficient $(k = \frac{Cx}{Ce})$;

Ce : gauge master capacitor (324pF) g : oil layer thickness [cm] ; S : capsule's surface [3,14 cm²] ε_0 = 0,0885 pF/cm2 ε_r : according to figure no. 2

The recorded oscillogram is presented as in figure 4: The value of Cp depends of the device's type and the utilized screened cable. After tying the cable's jacket, and the capsule to the central wire of the cable Cp can be measured. Inside the engine the sleeve bearing can be mounted (less the cable jacket's connection to the sleeve bearing's body), without cutting from the cable.

According to the registration presented in figure no. 4 results:

$Cx = k \cdot Ce$, [pF] $Cc = Cx - Cp$, [pF]

And the oil film thickness is $g = \frac{\varepsilon_r \cdot \varepsilon_0 \cdot S}{Cc}$ [cm]

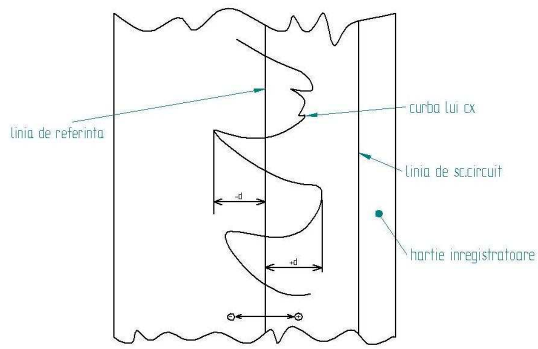

Figure 4

5. The method's accuracy

The method's accuracy is influenced by the type of the used instrumentation and the working manner. With the instrumentation earlier presented, and by statically checking the method with the help of, the electrically measured film is different from the mechanically measured one by +10%.

6. Conclusions

The checking method of the oil film thickness from the antifriction bearings offers the possibility of analyzing the manner of lubricating the bearing, allowing positive changes to be made.

References

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