EXPERIMENTAL STUDY ON ROUGHNESS PARAMETERS VARIATION, DURING RUNNING – IN PERIOD, FOR A CYLINDER-PLANE FRICTION COUPLE

Florin PETRESCU, Anton DAVIDESCU, Monica VLASE

Technical University of Civil Engineering of Bucharest,
Faculty of Technical Equipment, ROMANIA
www.utcb.ro

ABSTRACT

The studies of various lubrication problems have been recently focused on atypical geometrical and operating conditions (extreme conditions). Among these cases, one can find analyses of HD bearings having surface macroscopic defects. The aim of the present work is the analysis of the consequences (positives or negatives) of a transverse groove (representing an idealized surface defect) on the load capacity of a classical step bearing. The analytical and numerical (CFD) study of the bearing performance characteristics reveals that, for certain conditions, paradoxically, the defect is beneficial. A parametric analysis shows that optimum position of the groove leading edge is close to the step. These conclusions can be useful in studies of maintenance of lubricated friction couples.

Keywords: running-in period, roughness, load force, friction-wear.

1. GENERAL ASPECTS

It is well known the fact [4, 5] that during the running-in period, although carried out in the presence of a lubricant, the mutual interaction of the roughness can lead to an optimal roughness (roughness of equilibrium) and to an improvement of the superficial layer of the friction surface during the regular operation of the friction couple. Certainly, the running-in period must be carried out carefully and always in the presence of a lubricant. The principal requirements of an optimal running-in period are: gripping avoidance (even in an incipient state), degradation surfaces avoidance and a reduced period. In fact, it is a controlled wear period [2], very important for the couple durability and reliability.

This paper proposes a controlled running-in period of a TIMKEN couple surfaces, to provide for a continuous lubricant film, by providing an EHD regime or a partial EHD regime.

2. EXPERIMENTAL TESTS PROGRAMME

The test programme [3] using a TIMKEN equipment, (materializing a friction-slippage cylinder-plane couple), had in view the changes of the cylindrical surfaces micro-geometry during the running-in period. In the same time, the paper had in view the influence of the final mechanical working process of the cylindrical, active samples surfaces, on the tribological behavior. For this purpose, five parallelepipedic samples ($E_1$-$E_5$) and ten cylindrical samples (I1-I10) were used. Each one of the parallelepipedic samples has two active plane surfaces. The parallelepipedic samples as well as the cylindrical samples are made of OLC45-heat-treatable steel grade, and the final mechanical working process of the active surfaces was straight-line lapping (for the plane surfaces), finish turning (for the cylindrical surfaces of the I1-I4 samples), rough grinding (for the cylindrical surfaces of the I5-I7 samples) and finish
grinding (for the I8-I10 samples). As a lubricant, a mineral transmission oil – T90EP2 was used and the friction-slippage cylinder-plane couple was immersed in a tank filled with this lubricant; also, during all tests, the oil temperature was kept to a constant value \(T=40^\circ\text{C}\) and the same relative velocity \(v=3.83\text{ m/s}\) was used. Tests were carried out using two values of the normal load \(F_n\) (50 N and 100 N).

During the tests, cylindrical surfaces micro-geometry state and the lubricant film ratio were measured at 10, 30 and 60 minutes time intervals, respectively. The end of the running-in period can be estimated at 80% of lubricant film ratio value.

The cylindrical samples were coded (I1,…,I10). This first identification element is followed by the normal load value that reacts on the couple (5 daN or 10 daN). The third identification element refers to the running-in period at the end of which tribological parameters were determined (0, 10, 30 or 60 minutes).

Evidently, time zero means the initial samples state (as they were obtained in the final mechanical working process).

Thus, sample number I5.5.30 refers to the cylindrical surface state after a rough grinding process (as a final working process), at the end of the 30 minutes wear process, submitted to a normal load of 50 N.

The data analysis, regarding the samples micro-geometry state, was carried out at the Solid Mechanical Institute of the Romanian Academy, using an analogue-digitally measuring chain.

The measuring chain is composed of: Perthometer Profilometer (with a pick-up having a 5 \(\mu\text{m}\) top radius)\(\rightarrow\)Sampler (which has the role to retain, from the continuous variation of the electric signal sent by the pick-up, a finite number of signals called test samples)\(\rightarrow\)Analog-to-digital Converter\(\rightarrow\)Computer.

The analogical signal is filtered by a Butherword filter and after sampling with a Gauss filter in order to eliminate the surface dimples influence. The computer commands the sampling, memorizing and data processing.

Data processing was made using a specialized program, DISTR.64, which calculates the extremes number of the investigated micro-profile, \(N_{\text{eav}}\), traces the profilograme (for any \(L\) length), traces the Abbott-Firstone curve, traces the distribution curve of the micro-roughness height; calculates the roughness parameters: \(R_y\), \(R_z\), \(R_a\), \(R_q\) and \(R_{sk}\).

The images obtained during data processing are captured in GRAB.wpg files using a Screen Capture Utility/ WordPerfect Corp capturing program.

In order to study the micro-geometrical state evolution of the cylindrical samples during the running-in period, the top average radius of the micro-asperities and the average angle at the top of the micro-asperities had to be known, in different stages of the running-in period. Also, the parameters values of the lifting curve \((b\ \text{and}\ \nu)\) are determined by graphical processing of the digital load forces.

### 3. EXPERIMENTAL TESTS RESULTS

The curves of some parameters variation, shown above, are presented as following: figures 1-3 present the \(R_y\) parameter variation; figures 4-6 present the \(R_{sk}\) skewness parameter variation; figures 7-9 presents the variation of the average radius, \(r\), at the top of the micro-roughness; figures 10-12 present the average angle, \(\beta\), at the top of the micro-asperities; figures 13-18 present the evolution of the load force curve parameters, \(b\) and \(\nu\).

![Fig. 1](image1)

![Fig. 2](image2)

![Fig. 3](image3)

![Fig. 4](image4)
4. CONCLUSIONS

An interesting behaviour has the skewness factor \( (R_{sk}) \); its negative values indicate a micro-
geometrical profile asymmetry under the average line. That leads to an increasing real contact area with a
good load force power of the surface. All the samples indicate a strong decrease of the \( R_{sk} \) parameter in the
second test time period. At the end of the test period the \( R_{sk} \) parameter has negative values \((-2\)\), thus
indicating the end of the running-in period.

The average radius variation at the top of the
micro-roughness was always ascending for all the
samples. The maximum value was obtained for the
I1.5.60 sample \((r=24.6 \, \mu m)\), at the end of the
running-in period, but it had not the best tribological beha-
viour; the conclusion is that the radius value can
not be a parameter of appreciation of the friction
behaviour of the roughness surface.

The average angle at the micro-asperities top
\((\beta)\) has an decreasing value in the first interval of the
running-in period, and then an increasing evolution,
finally reaching bigger values than the initial one with
maximum 20\%; the biggest value has the I10 sample
\((\beta=176^\circ)\), sample that had the best tribological beha-
viour; the conclusion is that the \((\beta)\) parameter can be
used as an indicator of the friction behaviour.

Analysing figures 13-18 it can be noticed that \( b \)
parameter evolution, in all cases, is ascendent, but \( v \)
parameter has an increasing evolution in the first part
of the running-in period, then a decreasing on in the
last part of the running-in period. For the \( b \) parameter
the increasing value is very big for samples obtained
by turning, thus, the final value is almost 18 times
bigger than the initial value; for the grinding samples
the increase of the \( b \) parameter value is more mo-
drate (almost 7 times bigger). For the \( v \) parameter, the
final values are, for all the samples, inferior than the
initial ones; but the differences are smaller, of 70\%
maximum, for the turning samples, and of 100%
maximum for the grinded samples. This behaviour of
the load force curve parameters during the running-in
period (final values of the \( b \) parameter bigger than the
initial ones and smaller values of the parameter $\nu$ than the initial ones) leads to increase the convexity of the loading force curve and the movement of the inflexion point ($F_i$) of the load force curve, towards right. From a tribological point of view, this load force curve evolution is beneficial, because ensures a bigger real contact area and decreases the real contact pressure.

The correlation between the load force curve evolution and the negative values of the $R_d$ parameter, leads to the conclusion that concomitant with the real contact area increase, the lubrication is better, due to the increase of the surfaces capacity of lubricant retain (the negative asymmetry indicates a big volume of the contact surface gaps).

REFERENCES