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Contact Fatigue from Theory to Experiment

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Abstract

This paper aims to make an evidence of the main aspects regarding the deterioration of surfaces affected by contact fatigue. One possible way to reduce the deterioration of contact surfaces can be the option of the geometry of surfaces in contact, this paper containing the justification for using a certain type of test bar.

The trials for the contact fatigue were made using an original device having a test bar made of various materials with the same sizes and with different functioning methods.

Key words: *Contact fatigue, rolling, gliding*

Introduction

The contact fatigue is a complex phenomenon, caused by numerous factors which are in an interconditional relationship. Thus, a continuous and current concern develops on how to avoid the deterioration of bodies in contact which can eventually lead to incapacitating them or to serious accidents.

The fraying of surfaces through contact fatigue is based on the cyclical mechanical or thermo-mechanical stress overlapped with the movement caused by gliding, rolling, piercing or a combination of these movements. The prevailing movements are rolling or rolling with gliding. The occurrence of fraying through contact fatigue is dependent on the microscopic flaws related to the homogeneity of the material the surface is made of (inclusions of non-metallic carbides or air pockets) and on the flaws of the friction surface caused by mechanical processes (scratches, pinches, stains, holes) or by the abrasive fraying process.

The whole issue resorts to peak domains of nowadays science and technics, such as: the theory of elasticity and of contact between revolution bodies, methods for the elaboration of some calculus programs, specific statistical modalities for processing data, the theory of friction etc. „The Materials' Fatigue" studies the changes occurring within the mechanical features as a consequence of certain cyclic stress. The physical element that enables the analysis of fatigue stress is the crack.

In many bibliographical references, research has been made regarding the occurrence of cracks with various types of movements, various test pieces, various materials, various functioning types, the optimal functioning parameters for increasing reliability etc.

Possibilities of Reduction of Contact Fatigue Aging

The complex phenomenon of contact fatigue is determined both by constructive factors (material, geometry and the quality of the surface), and by exploitation factors (load, the type of lubricant used and the way it is used and the relative velocity).

a) The reduction of aging of the base material:

This is a measure which refers to the methods for elaborating and treating steel in order to obtain inclusions and finer and rounder air pockets, the orientation of fibers towards the rolling direction etc.

b) The durability, geometry and quality of the contact surface:

The distribution of tensions on the linear contact surface between two rolls is uniform in the case where the length of contact is infinitely great. In the real case, at the ends of the shorter roll with finite length there are maximum tensions, these areas being characterized as "weak" areas for contact fatigue.

The constructive measures that decrease the tensions peak are measures for increasing durability. Thus, for the rolling bodies having the shape of rolls (cylindrical or barrel), there are constructive modifications: conical extremities (Fig.1) the position, rounded ends with and without bevels (2 and 3), frontal releases (4) and the bulging of the rolling paths.

a) b)

Fig.1 Rolling bodies

The slow passing from a section to another through connecting rays, both for the rolling bodies as well as for the rolling paths (the connection between a linear contact area and a punctual contact area, or between punctual contact areas), modifies the distribution of tensions, leading to a significant increase of durability.

c) Lubrication conditions:

Regarding the influence of the quality of the contact surface (form irregularities, undulations and rugosities) over durability, we can notice the indirect dependency, through the lubrication conditions. When the conditions regarding velocity, load, lubricant and geometry do not allow the formation of some continuous lubricant pellicles, the quality of the contact surface and, especially the rugosities significantly influence durability. In this case, forces are transmitted through the peaks of the rugosities, thus creating tangent tensions and maximum normal on these peaks, which leads to the decrease of the degree of durability, the sources of defection being the rugosities themselves.

d) Durability and exploitation factors:

The geometric, cinematic elements of the punctual or linear couplings and the lubricant enable the occurrence of the elastohydrodynamic lubrication conditions. All conditions that favor the formation of the lubricant continuous pellicle are useful for the increase of resistance to fraying through contact fatigue.

Experimental Trials

The experimental study of contact fatigue is enabled by an equipment of experimental research comprising several functional modules. Everything starts from a test piece (Fig.2) similar to the one presented under figure 1b). The test pieces are made of various materials: Cu, OL37, OLC 45 (22-24 HRC) and OLC 45 (32-34HRC).

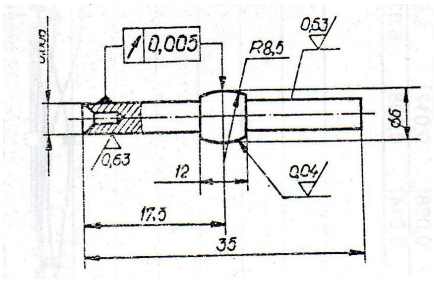

Fig.2 Test piece

For this particular test piece, the research team has designed, executed and tried out a stand (fig.3) in which the test piece is subject to a rolling movement, superposed by a static tangential and dynamic oscillatory force.

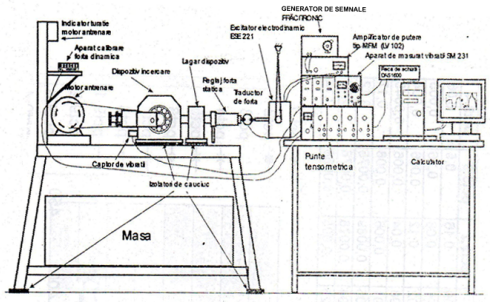

Fig.3 Test piece under rolling movement

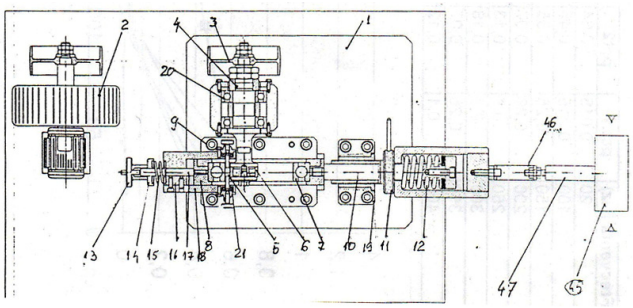

Fig.4 Experimental installation

This experimental installation (fig. 4), is composed of a fixed part (which creates the rolling movement of the test piece -5 with the help of the revolutions controller -2 through the driving belt -3, the leading shaft -4 placed on the bearing with radial bearings -20 and the leading roll -6, fixed at the end of the shaft) and a mobile part that causes the tangential tension over the test piece, that is static.(made through the following reference marks: 11-control socket, 12-elicoidal arch, control bar 10 and leading roll 7) and dynamic, due to the electrodynamic excitatory element 45, which, through the bar of 47 and the static adjustment (10,11,12) transmits the oscillatory tangential force.

Experimental Results

The experimental results were obtained over three measurement steps, as follows:

I – measurement of the response of the structure;

II – measurements made with $F_s = 0$ and $F_d = F_{d\max} \cong 70N$;

III – measurements made with the observance of the following proportion: $F_d = 1/10F_s$

The results obtained were concretized through graphs, as we can notice in Figures 5 and 6.

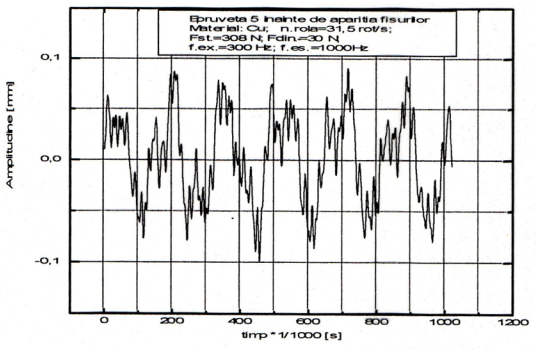

Fig.5 Experimental results

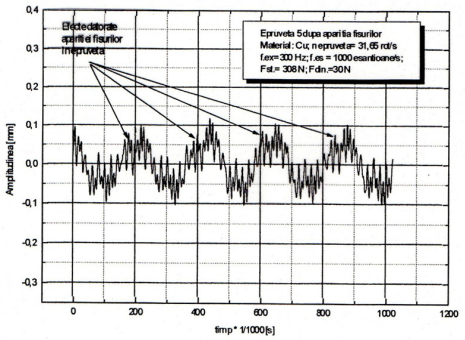

Fig.6 Experimental results

Conclusions

- The installation we designed, engineered and tried in the laboratory „Dynamics of machines" within the department of Materials Resistance and Vibrations of the „TRANSILVANIA" University of Braşov is complex;
- This installation can be used to apply stress to the test piece with very diverse cutting conditions, which simulate as well as possible the real conditions due to the fact that the rolling movement is superposed by a tangential force and a dynamic one;
- The test pieces used were made of relatively "soft" materials: Cu, OL37,OLC45 of two hardness degrees;
- The time of stress to the occurrence of the first fatigue signs was observed indirectly, through the change of the form of the vibration-signal;
- The main objective was the testing of the functionality of the installation, favoring the research of the fatigue phenomenon at high loads, thus at a reduced number of cycles;
- The installation can be used for the laboratory research of the fatigue phenomenon.

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Oboseala de contact, de la teorie la experiment

Rezumat

Lucrarea de faţă îşi propune trecerea în revistă a aspectelor principale cu privire la deteriorarea suprafeţelor la oboseala de contact. O posibilitate de reducere a deteriorării suprafeţelor de contact poate fi alegerea geometriei suprafeţelor în contact, în lucrare apărând justificarea folosirii unui anumit tip de epruvetă.
Încercările la oboseala de contact s-au făcut cu un dispozitiv original cu o epruvetă din diferite materiale cu aceleaşi dimensiuni şi cu regimuri diferite de funcţionare.