TEST STANDS AND METHODS FOR INVESTIGATING THE FRETTING PHENOMENON

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Abstract. *Fretting as a damaging way of the surface in contact is known for over 80 years. In the last 20 years there have been important achievements in the experimental research, understanding and description of the mechanisms that lead to this phenomenon. From the definition of the phenomenon of fretting and the study of the influence of various factors on fretting it was concluded that the main factor in the occurrence of fretting is the existence of the relative oscillating movement of small and very small amplitude between the contact surfaces under the action of a normal tasks.*

Keyword: fretting, fretting-wear, fretting-fatigue, investigation.

1. Introduction

The phenomenon of fretting is part of the category of phenomena at which, at least until now, experimental research is the only source of information on the phenomenon, while providing the data on the basis of which some conclusions were drawn about the mechanism of production of fretting as well as its connection with influence factors (amplitude, normal load, alternating voltage, number of operating cycles, lubrication, environment, etc.). The complexity of the fretting phenomenon has so far not been quantifiable, except for temperature, coefficient of friction and some particular cases of fretting fatigue. There have been some attempts to quantify wear in fretting conditions starting from one of the fundamental types of wear, which is unacceptable given the complex character of the wear of fretting [1], [2]

Under these circumstances, the judgments issued and the conclusions drawn were exclusively based on the results of the experimental research.

2. Friction coupling used in the study of the phenomenon of fretting

In both the general and the particular study of the phenomenon of fretting, researchers used friction couplings from all four classes. The most commonly used were Class Ia friction couplings with spherical / plane type contact ([3], [4], [5] etc.) or cylinder / cross ([6]), etc.

These friction couplings are the most used due to the advantages of point contact, the actual contact area can be considered to be approximately equal to the apparent contact area, the possibility of more accurately assessing local stresses, avoiding the problems of coupling centers and uneven loading of the surfaces contact.

Also, the spherical / planar contact best describes the mechanism of the fretting phenomenon characterized by the existence of the three fretting-specific regimes (regions): I-soldering, II-partial sliding, III-sliding total.

Sometimes these couplings have been used to model fretting that occurs in particular machine organs - for example, ball bearings that work in quasi-static or oscillating mode, and their multifilament cables - their fretting being modeled by the cylinder / cylinder friction coupler.

Friction coupling from the II class, with linear contact , type cylinder / plane are also used to investigate fretting, but to a much less extent ([7]).

The lowest use in the study of the phenomenon of fretting is represented by the class III friction couplers [8],[9]. This is probably because of the execution difficulties (the contact surface is a curve) and the lack of control over the uniformity of the contact surface load.

Along with the Class I friction couplers, those in the fourth grade with plan / plane type are relatively more used in the experimental study of fretting. [10].

These couplings are the most comfortable in terms of geometry execution and measurement, being used in particular in studying the wear of fretting and in studying the formation and influence of the third body in the process of fretting.

3. Methods and apparatus for general investigation of the phenomenon of fretting.

From the definition of the phenomenon of fretting and the study of the influence of various factors on fretting it was concluded that the main factor in the occurrence of fretting is the existence of the relative oscillating movement of small and very small amplitude between the contact surfaces under the action of a normal tasks.

This oscillatory motion can generally be achieved in three ways [11]:

- mechanically by means of an eccentric mechanism;
- mechanically via a hydraulic vibrator;
- electrically with an electromagnetic or electrodynamic vibrator;
- magnetic by magnetostrictive effect.

All of this, however, is included in a complex installation with various assemblies, joints, bearings, etc. Mechanical devices generally have gaming and stiffness which, even under moderate loads, can easily take off this size order. Therefore, it can be difficult to ensure that the above mentioned shifts take place at the interface and not elsewhere.

Therefore, the relative sliding amplitude will be influenced by the rigidity of the test machine, the frictional force and all its influence factors. It would therefore be desirable to properly measure the sliding amplitude during the experiment on the interface, which is not easy to do. Mostly the measured displacements are recorded at a considerable distance from the fretting contact and are the displacements of the sample holder, thus including parasitic displacements not negligible.

The most sensitive in this respect are those installations that have elastic straps in their composition, proving that the displacements up to 50mm were completely absorbed by the straps, without the fretting appearing [12], [13]. Therefore, the great importance of increasing the stiffness of the experimental research platforms of fretting is justified.

As far as the normal contact load is concerned, it is obtained by means of well-sized weights, by the force of an elastic element (spring), by the pressure of a fluid (oil), etc.

It has to pay attention to the contact load, as it can significantly influence wear. A constant normal load does not mean a real pressure of constant contact as the latter decreases with increasing wear "scar", so with the real contact area.

The installations listed below were used either for the research of fretting in general terms or for the study of both wear and fatigue of fretting.

Nowell and Hills [14] (1961, 1987, 1989, 1990, 1992), using Bramhall's work, used a test procedure consisting in requesting to alternately draw a symmetrical specimen with a fixed pitch under two cylindrical patches, by one spring, and placed on each side of the specimens. The skates are embedded in an assembly that prevents all spins. The connections to the springs can be permanently adjusted so that they can control the amplitude of the tangential force Q. With this embodiment, the tangential force Q is in phase with the applied fatigue voltage.

This experimental device is similar to that used by Endo and Goto (1976) and Nishioka and Hirakawa (1969) Fig.1.

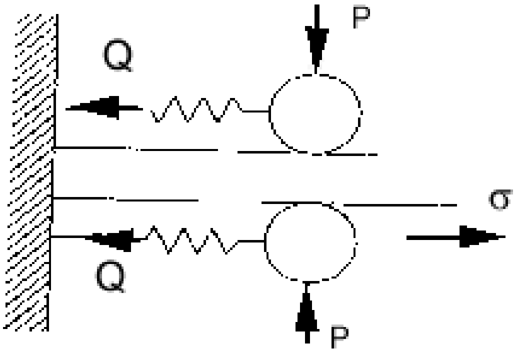

Fig.1 (a) Schematic representation of the experimental device used by Nowell and Hills (1988, 1989, 1990, 1992) 1961 [14]

M.Liraut [15] uses, for the attempt at fretting, an assembly initially used by Colombia. In Fig.2, the schematic diagram of an apparatus used for imposing small displacements is presented. An experimental yarn (1) integral with the piston (3) is animated by an alternate movement of shape and amplitude. The second fixed test fixture is integral with the bead by means of a movable carriage (4), allowing for the application of a normal effort.

They imposed:

- displacements (+/- D) controlled by a tensometer.
- normal effort (P).

Measurement parameters

- the tangential force (F) measured by a piston (5).

The normal effort is imposed by a mobile stroller (4) at the beginning of the tests via the loading rectangle (6).

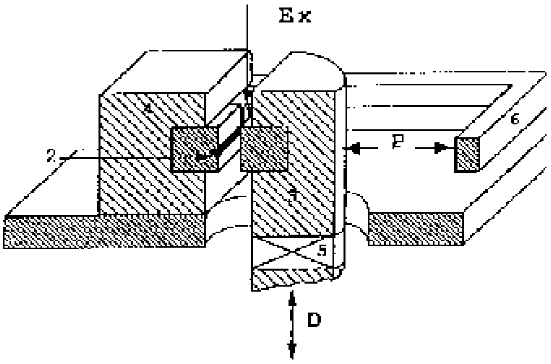

Fig.2. PIU Test Pattern Scheme on MTS Machine [15]

M. Zhong [16] used a device developed by Ch. Colombie to investigate the phenomenon of fretting [17](fig.3). It consists of the possibility of applying an alternative small amplitude movement to two specimens, one fixed to a rigid bar, another to a piston driven by a hydraulic machine and animated by an alternative movement of shape and amplitude data. Normal effort is applied by means of a loading rectangle and is measured continuously throughout the tests.

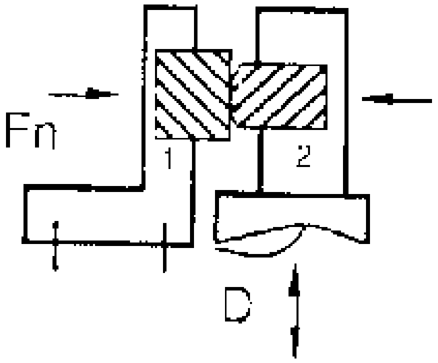

Fig.3. The device of the test apparatus [16]

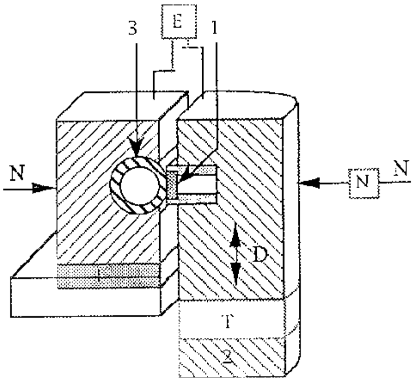

Fig.4. "Standard" test assembly [18]

The contact is of the curved-plane type. The flat surface is a 12 x 10 x 10 mm parallelepiped. The bulbous sample is obtained by polishing a spherical surface of radius R = 0.5 mm.

Continuous recording of Ft tangential effort. Depending on the displacement D during the tests, it allows the tracing of the FtD cycles in each assembly.

Using the same test principle (Colombia, 1986), J.M. Voisin [18] requires a low-amplitude alternating rectilinear motion to two samples previously placed in an unloaded contact.

The schematic of the device is given in Figure 4, the first specimen (1) being fixed to the plunger (2). The second specimen (3) is connected to a mobile frame (4).

Normal effort is applied to specimens by means of a rectangle of loading. The device (1) is animated in an alternate motion.

The tensometer (E) controls the displacement of the piston. Two collectors (N, T) continuously measure the values of normal and tangential stresses at contact level.

The geometry of the contact is of the type of cross-axle cylinder. The dimensional characteristics of the specimens are the same (the same surfaces and the same dimensions).

For the mobile sample the displacement is parallel to the generator, for the fixed specimen is perpendicular. This results in a particular situation for each sample.

To study the behavior of fretting with Ti2N - K. coatings, De Bruyn [19] uses a fretting testing apparatus presented in Fig. 5.

The frictional force was measured continuously by means of a piezoelectric transducer. The wear pattern was observed in an optical microscope. [20]The amount of wear was determined using a Radenstock RM 600 laser beam. The scanning was performed both perpendicularly and along the axis. The authors compared the wear traces following the fretting tests for Ti_2N and TiN coatings.

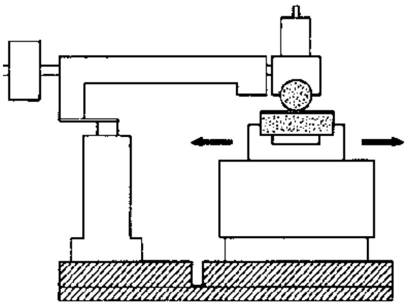

Fig.5. The device for fretting tests. [19]

R.F.Baker [21] studies steel wear wear using a model shown in Fig.6.

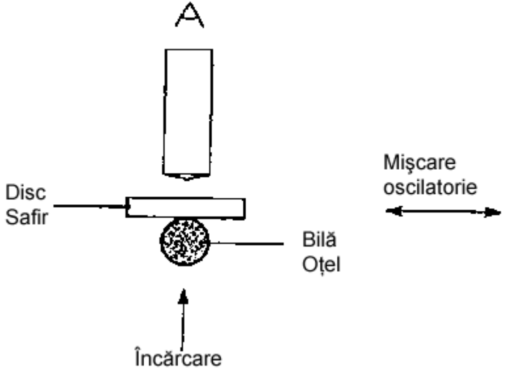

Fig.6. Schematic diagram of the steel sapphire couple [21]

The use of a transparent surface allowed direct observation of the movement of debris and wear inside the contact. [22], [23]

4. Conclusions:

Sphere / plan contact puts (experimental research) the best evidence of the fretting mechanism characterized by the three regimes: I-soldering, II-sliding partial, III-sliding total.

From the research of the present experimental stands, three possibilities of action were separated:

-mechanically, with the help of an eccentric mechanism

-mechically, by means of a hydraulic vibrator

-electric, using an electromagnetic or electrodinamic vibrator

-magnetic, by magnetorestrictive effect.

- measurements of relative displacements are generally carried out at a certain distance from the point of contact, which can give rise to negative influences on the study of the phenomenon of fretting because we can not know precisely the displacement from the contact point, the order of magnitude of the movements as a part from them to be absorbed by the games and rigidity of the system.

The normal contact load can be obtained by means of a well-known weight, by means of an elastic element (spring) or by means of a fluid (oil).

For a proper study of the phenomenon of fretting, we must keep in mind that for a normal contact force, the actual contact pressure is not constant, decreasing with the increase of wear "scar", so with the real contact area.

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