Effect of dynamic response of fretting devices on the fretting results

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Fretting damage phenomenon results from the oscillatory motion of small amplitude occurring between contacting surfaces and is a usual damage mechanism in a wide range of mechanical components and structural parts.

Depending on the materials, the contact conditions and the environmental effects the damage can occur by different mechanisms, namely: fretting wear, fretting fatigue and fretting corrosion.

The research on fretting subject involves theoretical studies by classical contact models from Mindlin and Hamilton [1] or finite element analysis and experimental studies. The results of experimental studies often appear as fretting maps [2] or are expressed in terms of energy. The energy approach uses the work developed by the friction force as a measure of the input energy on the system and search if the damage, mainly the wear damage, is directly related to the input energy.

Wear and friction measurements reveal in general a leak of repeatability in inter-laboratory comparison [3]. The control of the test variables, the atmosphere and also the test procedure can play an important role on the results reliability. However, the vibration on the contact specimens and transient responses on the electric signal of the physical quantities, so the dynamic response of the equipment and of the measurement system can have a great influence on the results. In the fretting experimental studies these effects have a particular importance due to the frequency levels usual used on this kind of tests.

In spite of for pin-on-disc tests some studies have been carried out to study the influence of some dynamic aspects on the wear and friction results [4], for fretting tests and more specifically for the dynamic response of measurement systems, in our knowledge, no works have been yet published. So, the aim of this work is verifying if the dynamic response of fretting devices have an important effect on the fretting results, mainly on the friction force.

In general the fretting tests were carried out in displacement control. Thus, the test rigs impose to the specimens in contact a harmonic displacement. The friction force arising on the contact has a fundamental frequency equal to the frequency of the applied displacement. On the majority of test equipment's, the usual solution to determine the friction force is the measurement of the balancing force necessary to stabilise the stationary specimen holder.

To study the dynamic response of the measurement system a lumped mass-spring-damping model is used. In such a system the load cell measure in each time the force transmitted to the foundation. By means of the general dynamic approach, well described in the classical vibration books [5], the measured force F_t appear as proportional to the friction force F and have an harmonic variation with the same frequency but with a phase difference angle of ϕ.

The relationship between the amplitude of the measured force and the friction force, usually called transmissibility depends on the frequency of the test and on damping factor of the measurement system

For systems with low damping, the amplitude of the measured force is similar to those of the friction force only for tests with frequency values lowest than the natural frequency of the measurement system. Increasing the test frequency, there is a strong amplification effect for frequency values in the vicinity of the natural frequency and after for the highest values the measured value can be very lowest than the friction force. So, in practical terms, the amplitude of the measured force is equal to the friction force, which value will be evaluated, only for the lower frequency tests. To have a good linearity of the measuring system for a wide range of frequency is necessary to have a high damping and this solution is usually incompatible with the required frequency response and stiffness.

Some experiments have been carried out with 2024-T6 aluminium alloy, tested against a composite material of polypropylene matrix and type-E glass fibre. This tests reveals that the effect of the dynamic response on the results can be corrected using the transmissibility law derived for the tangential force measurement system of the used test rig.

As concluding remarks some rules must be fulfilled to achieve the better results and a suitable reliability of the test results. The dynamic response of the fretting equipment's can significantly change the friction force measurements. The transmissibility law derived for the tangential force measurement system of the used test rig seems to be suitable to correct the tangential force acquired values.

References

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