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Equivalent vibration tests

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Abstract

The requirements for test results on vibration authenticity and reproducibility are discussed. Experimental results of longevity and vibration loading (fatigue curves and curves of the "vibration loading") of a 10 deterministic and random modes of vibration, done by a special technique with new sensors and the test equipment, were obtained. The deterministic and random modes equivalence coefficient much increases with the time before the destruction of the sample. It is shown that the "equivalent" replacement of a deterministic model of a random loading when tested on vibration loading is unacceptable. The model replacement when tested on durability is allowed only for polyharmonic mode but is incorrect.

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Keywords: broadband casual vibration; equivalent vibration tests; stresses; deformation; vibration speed; sensor; durability;

1. Introduction

The last decade has been characterized by a sharp increase in power and speed of transport equipment. This causes an increase in vibration loading on constructions because of the occurrence of turbulent flow, pressure fluctuations in the engines and the forces of interaction with the environment. These factors cause the deterministic and random vibrations. More than 70% of failures are caused by vibration in engineering, because of which fatigue destruction of construction elements transported goods, failures and malfunctions of electronic equipment occur.

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The operating conditions of some objects (missiles, space vehicles, submarines, aircraft, etc.) and the growing shortage of metal in the world require a reduction of weight of the metal in constructions. Finding a reasonable compromise of the maximum reliability with minimum weight is laid in the development of methods for determining the adequate behavior of materials in the construction with a specified service life and reliability.

In testing for the vibration there are two major problems.

- Obtaining the reliable fatigue curves of the material at loads**,** close to any operational conditions, the study of the construction vibration loading and the prediction based on their durability test.
- Evaluation of reliability and strength of the vibration test facility for a specified time under specified loads. At the same time for completion of the tests there is no reliable data on the remaining resource of the object, and to bring a construction to the destruction, many of which are unique, is too expensive.

But there is a general tendency - the desire to simulate the operational condition of the random vibration loading. During the operation of transport vehicles the most common type of load is the broadband random vibration.

The International Electrotechnical Commission (IEC) imposes on the vibration test two basic requirements: reliability of the results and their reproducibility in different laboratories, which is especially important during the acceptance testing [1]. The reproducibility of test results is not realistic at a low reliability of the results.

In the development of methodology of the vibration test, there were new problems [2], including equivalent tests, by these we mean the actual replacement of the random vibration by the deterministic test condition. The research in this direction was made in order to reduce the cost of testing, because energy consumption under random vibration increase in an order of magnitude or more compared with the deterministic vibrations. The tests conducted in some cases many days.

The problem of replacing the random vibration by the deterministic process is considered in the theoretical aspect [3, 4], and in terms of hardware reproduction [2, 5] and standardization of tests [6, 7]. There have been made a huge number of experimental studies [8, 9, 10, 11 etc]**,** however, a universal solution to this problem was not found. However, in industry deterministic modes are used until now. And if the equirements of the IEC to the reproducibility of test results for harmonic loads are not difficult to satisfy, the degree of reliability of the results of such tests has caused some doubt [12]. In works [8-11 etc.] strain sensors were used earlier and are used now for strain measuring. These sensors accumulate damage as the measuring object at prolonged vibration loading [13,14]. Therefore, strain sensors change their metrological characteristics.

However, these methods of tests are applied till now [15, 16, 17 etc].

To establish the reliability of the results of equivalent tests is possible with the results of fatigue tests on similar modes, because the reliable criterion of equivalence is just time before destruction. The reliability of the results of fatigue tests can be improved by perfecting test and measurement equipment and test procedures, using the test conditions close to real life.

Let us consider the experimental results in the destruction of cantilevered fixed beams of alloy AMg6 according to method [18], which contains requirements for testing the vibration loading, and the longevity on the deterministic resonant modes (Fig. 1, № 1, 9 and № 2, 10), on the narrowband (№ 3 and № 4) and on the broadband random mode with a continuous spectrum (№ 5 ... 8). № 9 and № 10 in figures show for the first time in practice of research presents the results of fatigue tests on the harmonic and polyharmonic modes. These modes are formed by the device that supports the given value of deformation during the test [19]. The results of these modes differ significantly from traditional modes results in № 1 and № 2 constant value of the vibration velocity, obtained by statistical processing of measurements of deformation.

The deformation was measured with a non-contact capacitive deformation sensor [20], which, unlike the resistive-strain sensor is not deformed along with the object of testing and does not change its metrological characteristics in the long process of loading. Test method [18], unlike most others, does not contain any schematization of random processes.

On the basis of this material representing all kinds of operational loading, let us analyze the reliability of the results of equivalent tests of vibration loading and durability.