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Vibroacoustic parameters of advanced materials and systems to reduce vibrations in the work environment

Abstract of doctoral thesis

Among many methods of limiting the mechanical vibration hazards at workstations, the only solution is often to reduce the transmission of vibrations into the employee's body by putting vibration-isolating materials between the source of vibration and the human body. Such materials can be used for the construction of protective means such as anti-vibration gloves, covers of the handles of hand tools, seat inserts, footpads, vibration-isolating platforms, etc. The basic materials used in the protection of the employee's body against vibration hazards are polymers, wools, fibrous, textile, porous, natural materials, etc. Advanced materials – new materials and any modifications of the existing ones, which are used for obtaining better properties in terms of one or more features that determine their use under certain conditions, they are usually not tested for their applicability as anti-vibration means. Sometimes the materials do not meet the criteria qualifying them as anti-vibration protection but they can be used as an element of vibration reduction systems.

Despite the wide range of available materials for vibration attenuation, there are large differences in the researchers' approach to their selection and the test methodology. The lack of a unified test method makes it difficult to quantify the damping properties of the tested materials. Therefore, a task was undertaken, the aim of which was to determine the vibroacoustic parameters of advanced materials and systems in terms of their use to protect against mechanical vibration at workstations.

As part of the dissertation, laboratory tests on the developed test stand were carried out. On the basis on the tests, parameters (e.g. stiffness, damping, dispersion) characterizing the vibro-isolating properties of the tested materials were determined. Research of vibroacoustic parameters was carried out for 33 advanced materials/systems.

The accelerated ageing test of selected material samples was carried out to check the preservation of their anti-vibration properties and strength parameters with time. The samples for which deterioration of vibro-isolating properties in the entire tested frequency range, compared to the characteristics obtained before the accelerated ageing test, were rejected.

Additional tests of physical and mechanical properties for selected material samples, based on graphs of stabilized hysteresis loops were carried out. The purpose of these tests was to determine the stiffness coefficients (k) and comparing them with the values of the stiffness coefficients (K) determined using the method described in the dissertation. A significant influence of the surface area of the material sample on the test results was

observed. Stiffness coefficients determined based on the resonance curve method, reached similar values to the stiffness coefficients determined based on the graphs of stabilized hysteresis loops but only after the surface area of the samples has been reduced to the dimensions of the samples tested on a fatigue testing system. The values of stiffness coefficients obtained with both methods, for different sizes of the sample surface areas, differ many times. This is due to the classic approach to the issue of vibration isolation, consisting in the assumption of the linearity of the vibration isolation system, without taking into account the volumetric elasticity coefficient related to Young's modulus E and Poisson's ratio ν of the tested materials, and reducing the dynamics of the system to a discrete model with one degree of freedom.

In order to check the possibility of determining the computationally vertical vibration displacement of the test weight during the tests of vibration transmissibility of resilient materials simulation tests were carried out. The relative differences between the maximum and minimum displacement amplitudes indicate that the results obtained with this simulation method only allow roughly estimate the displacement of the test weight based on the given material parameters (stiffness and damping) of the tested sample.

As a result of the doctoral dissertation, the values of transmissibility coefficients for the tested materials and systems were determined. On the basis on this parameters, the vibration attenuation of tested materials/systems was assessed (in a three-degree scale) for workstations where the employee is exposed to whole-body and hand-arm vibration.

For each material/system tested on real workstations frequency ranges in which it showed a reduction of vibration in three measurement directions were determined. It has been observed that it is not possible to determine one frequency range in which the attenuation of vibration by the material/system under real conditions occurs. Such frequency ranges for the same material or system are different and depending on the workstation where it is applied. This is related to the type of vibration occurring at the workstation, dominant frequencies or the occurrence of resonances. Although usually classic (passive) vibration isolation does not provide a satisfactory solution to the problem of vibration reduction in the case of low-frequency excitations, after the use of tested advanced materials/systems on one of the workstations, for five samples, a satisfactory reduction of vibration in the frequency range from 0.9 to 90 Hz was estimated.

The obtained frequency characteristics of the transmissibilities and the designated frequency ranges of the reduction and amplification of vibration in advanced materials/systems may facilitate the assessment of their suitability for protection against vibrations in the work environment or as an element of vibration isolation of machines/devices.

The research carried out confirmed the thesis that with the use of advanced materials and systems it is possible to reduce mechanical vibration at workstations in a defined frequency range and under specific conditions of use.