Practical aspects in measuring vibration damping of isotropic materials

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ABSTRACT

Material damping is the ability of a material to suppress vibrational energy. Vibrations have many sources, from large scale earth quakes to an unbalanced rotating machine. Some applications, at which vibrations may cause damage to the environment or machine, need accurate knowledge of the damping capacity of a material. The challenging task then is to assess damping in a quantitative way. Damping is influenced by many parameters such as temperature, frequency, strain rate, etc. and these must certainly be taken into account when measuring damping. But even in this latter aspect, determining damping in an experimental way, some issues come up. This work takes a closer look to which practical aspects have an influence on the damping capacity measured with the free-vibration method.

INTRODUCTION

Any vibration wave propagating through a material loses energy because of the internal damping of the material. The damping capacity does not only depend on the material type but also on parameters such as temperature, strain rate and frequency. Because of this, the damping capacity of materials is best quantified by experimental tests. However, even then big differences exist in literature on the damping capacity found of the same material, indicating there should be some practical aspects in measuring damping which influence the final result (Zhang, Perez, & J., 1993). In this work, the free vibration method is put forward to investigate for its pros and contras. A variation in test cases on (i) excitation, (ii) response measurement and (iii) suspension of the specimen under test is put forward for evaluation of their influence on the measured damping.

RESULTS AND CONCLUSIONS

Determining damping with the free vibration method implies that the specimen under test should have an excitation which brings the specimen out of his equilibrium position, if then the excitation is released a monitoring device must track the response of the specimen. The specimen will oscillate around its zero-position for a number of cycles with decaying amplitude. The damping capacity is assessed by the logarithmic decrement method, it is a measure of the rate of the decaying amplitude from the oscillating sample. This logarithmic decrement δ corresponds to a viscous damping ratio as $\varsigma = \delta / 2\pi$. In a first method, a steel rectangular sample is clamped on the armature of an electrodynamic shaker (Fig. 1). A triangular shock excitation brings the specimen out of equilibrium state and response is measured with an accelerometer at the end of the specimen. Placing the response accelerometer at the end of the specimen gives most amplitude, but on the other hand this increases also the added mass effect of the accelerometer on the specimen. Especially with low Young’s modulus materials this effect will be more pronounced. This effect even increases if the wire of the accelerometer is not proper guided on the sample, the measured damping ratio more than doubles if the wire is attached as in Fig. 2. Another shortcoming in free vibration testing with a shaker is the inherent damping of the armature in the coil of the shaker and the armature is also not rigidly fixed in the shaker making the resonant frequencies of the specimen to shift. Such experiments at a steel and aluminium specimen showed that steel has a damping ratio twice as high of the aluminium specimen (Vanwalleghem, 2009-2010). Therefrom is concluded that this method of measuring damping is not the right one. Apart from shaker testing, there are other points the experimenter should pay attention to also. Firstly, free vibration testing with a cantilever beam requires proper clamping of the specimen to avoid additional damping due to sliding of the specimen in between the clamping mechanism. The second aspect is related to impact (or shock) excitation. The transient visible at the response signal contains high frequency components superimposed on the lowest resonant frequency, as can be seen at Fig. 3. These high frequency components dampen out fast and finally only one single frequency component remains of which then the damping ratio can be assessed. Thus this kind of excitation in a free vibration experiment leads to knowledge on the damping capacity of only the lowest resonant frequency.

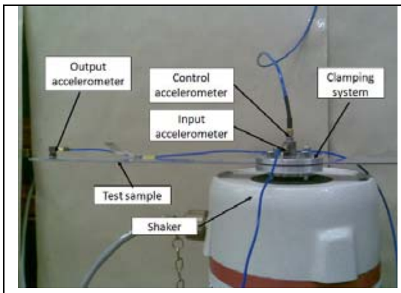

Fig. 1: Test setup with shaker excitation

Fig. 2: Mounting accelerometer on specimen

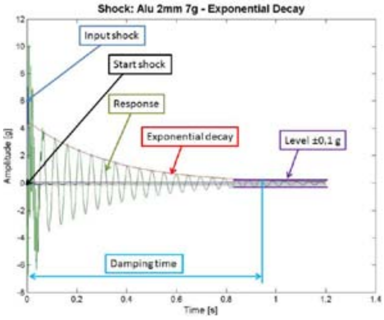

Fig. 3: Response signal from shock excitation

To overcome all these findings, it is opted for non-contact making excitation and response measurement, respectively with a loudspeaker and a laser Doppler vibrometer. Also, the influence of clamping systems is minimized by suspending the specimen by very thin nylon wires. Again, practical issues are found in correct measuring damping. The boundary conditions, even with thin nylon cords, play a distinct role. Attaching the cords at the anti-nodal location or nodal location of the corresponding mode shape led to a 60% difference in damping ratio at the first resonant frequency from a steel plate of 320x320x2mm. Fig. 4 shows the exponential decay of the response signal in both cases.

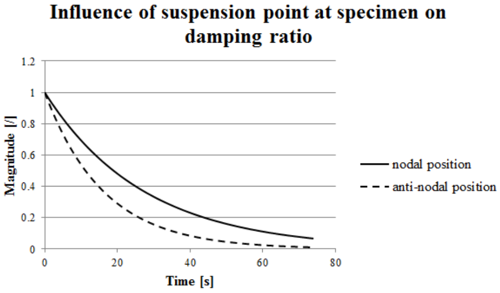

Fig. 4: Exponential decay in free vibration testing and the influence of the suspension points

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