# THERMOMECHANICAL BEHAVIOR OF BEAMS COVERED WITH VISCOELASTIC PATCHES

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## 1. Summary

Infrared thermography is a non-destructive test method based on infrared measurement that provides a luminance map of the thermal scene observed, converting to temperature. The thermographic study allows a surface observation of the thermal effects in order to display the result as a film of the temperature distribution [1].

The present study focuses on the detection of volumetric energy sources in beams covered by viscoelastic patches. The objective is to establish a relationship between the mechanical energy dissipated by patches and the temperature elevation, which occurs in areas of high deformations and appears on the surface by thermal conduction [2].

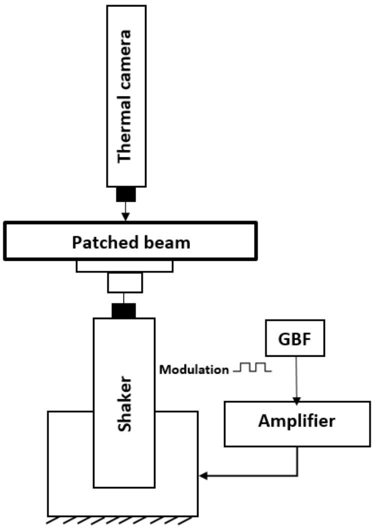

**Figure 1: Experimental device**

The experimental device is composed of a thermal camera, an aluminum patched beam, a shaker, a generator and a power amplifier.

During the experimental study, an infrared thermal camera was used to obtain a thermal field of the beam surface covered with the patch, without direct contact with the equipment. The aluminum beam (200 x 16 x 1 mm$^3$) is covered with a black paint of high emissivity.

The viscoelastic patch consists of two layers: a first layer of thickness 0.5 mm, consisting of a viscoelastic material and a second aluminum layer of thickness 0.2 mm. The viscoelastic material has a density of 1190 kg / m$^3$, a Poisson's ratio of 0.45 and a Young's modulus of 10 MPa.

This energy study was conducted successively at a frequency near the first and the second mode of the patched beam, because more energy is stored in lower order (frequency) modes.

These modes, whose frequency around 20 Hz and 155 Hz, have been identified by a vibration test using an accelerometer and a laser doppler vibrometer (ldv) [3]. The excitation signal was a sine modulated by rectangular signal whose period is around ten seconds. The purpose is to measure the evolution of the surface temperature of the beam, as a function of time.

These tests were performed to observe the response of the viscoelastic material to the stresses appearing in it according to the vibrations undergone. The temperature measurements are made on several zones of 20x20 pixels (corresponding to approximately about 1cm$^2$) along the beam.

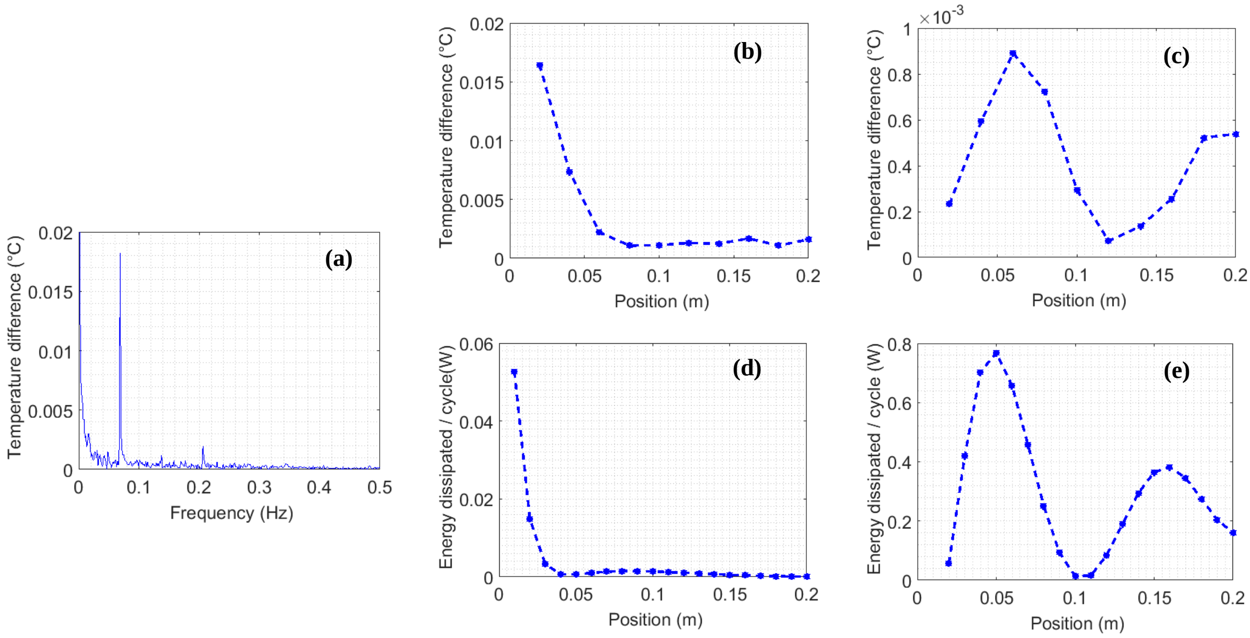

**Figure 2: (a) Module of Fourier transform of temperature, Temperature evolution vs position: (b) first mode and (c) second mode, Energy dissipated per cycle: (d) first mode and (e) second mode, calculated with the software Actran.**

Because of small temperature differences, and to minimize random noise, averages were calculated on each zone. Fourier transform calculation allows to highlight these differences in temperature, dependent on the modulation frequency (Figure 2a).

Several measurements were conducted along the beam to correlate the temperature difference (Figure 2b and 2c) and the dissipated mechanical volumetric energy generation in the viscoelastic patch (Figure 2d and 2e). Depending on the position of the treatment zones, it is observed that the temperature decreases and the beam dissipates less energy (Figure 2b and 2c). Therefore, we can say that, for the first two modes of vibration, the temperature and the energy have approximately the same profile.

By a reverse method, it is possible, depending on the surface temperature field, to obtain the location of the power density [4]. Therefore, the areas of high mechanical stress in the viscoelastic patch can be localized.

These experimental tests provide information to better understand the behavior of viscoelastic patches according to the mode of the studied structure and especially to verify by a non-contact measurement the efficiency of patch position.

Such studies based on experiment and numerical modeling could be useful, in future work, to optimize positions and dimensions of viscoelastic patches and to locate sticking problems of patches on different structures.

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