Characterisation of single fibre's mechanical behaviour under vibrational testing

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ABSTRACT

Driven by growing environmental concerns, there is a clear shift towards developing lighter, safer, and more eco-friendly structures. In this context, significant progress is being made in the field of composites, particularly in the development of plant fibre-reinforced composites. These advancements not only address ecological challenges but also seek to enhance mechanical properties, such as damping and storage modulus. However, understanding these properties within plant fibre-reinforced composites remains a significant challenge of importance. To fully understand damping at the composite scale, it is essential to investigate the energy dissipation mechanisms occurring at each level of the material's structure. In the literature, potential sources of damping, including the matrix, the fibres, and the interfaces between fibres (fibres/fibres and fibres/matrix) are identified. This study specifically focuses on fibres as a key source of energy dissipation. However, measuring the mechanical characteristics of individual plant fibres is particularly challenging due to their small scale (approximately 10 µm in diameter and only a few millimetres in length), which introduces uncertainties in their properties. To fill this knowledge gap, this study proposes a method based on the dynamic response of individual plant fibres. The experimental setup uses a piezoelectric actuator to excite the elementary fibre, while a high-speed camera captures its response in real time (see Figure 1). The fibres selected for these tests include E-glass fibres, PA11 fibres (polyamide 11), and flax fibres, ensuring a wide range of material properties. An image correlation program tracks displacements along the fibre, facilitating a detailed study of its damping and rigidity characteristics. This setup controls the fibre's environment during excitation, enabling observation of the effects of variables such as pressure, humidity, and temperature on damping behaviour. A vacuum chamber and pumping system were developed, allowing experiments in vacuum conditions. By using this method, the goal is to gain deeper insights into the mechanical properties of plant fibres, ultimately supporting the optimization of plant fibre-reinforced composite materials for more effective design and performance.

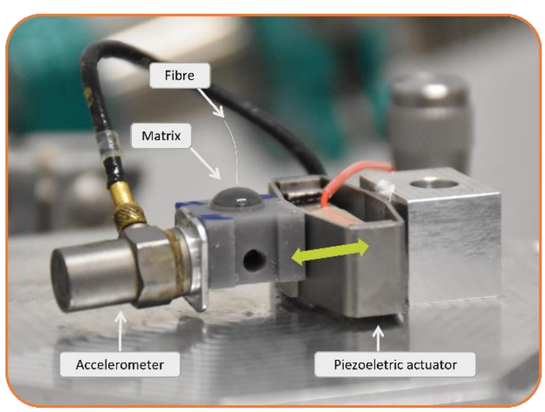

Figure 1: Experimental set-up for damping characterisation under vibration tests

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