Experimental investigations and nonlinear characterization of PLA-based beams

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Abstract. Structures and parts are more commonly being fabricated using additive manufacturing (AM) due to low material waste, ability to quickly generate prototypes, and potential to create complex geometries that would otherwise be difficult to manufacture. While there are many benefits to using AM processes, the overall behavior of the structure is dependent upon the orientation of the construction. Some materials, such as the common 3D printing filament Polylactic Acid (PLA), are anisotropic materials. Anisotropic materials have often been simplified and represented as isotropic materials to simplify the calculation of numerical models. Isotropic material models are defined using three engineering constants which are uniform in each of the material's principle directions; fully anisotropic material models are defined using 21 independent elastic stiffness parameters [1]. While such an assumption may be valid in some cases, this study seeks to characterize the nonlinear response due to large deformation of a cantilever beam with a symmetric tip mass and varying filament printing angles. The nonlinear dynamic characteristics are acquired using harmonic and random forced vibration experiments.

Introduction

The applications for additive manufacturing range from building large structures, such as houses down to nanotechnology. AM technology is readily available at low costs to industrialists and hobbyists alike due to its recent rise in popularity amongst the industrial and commercial world. There are many benefits to using AM processes, but the overall material properties and behaviour of the structure are dependent upon the orientation of the construction [2]. In the case of AM, one must consider the system dimensions and geometries, additively manufactured material properties, the orientation of the part, extrusion temperature, etc. Many AM materials are anisotropic, but this is not often considered during the design process. In this effort, the nonlinear dynamic effects of beams are analyzed using PLA materials, as shown in Figure 1.

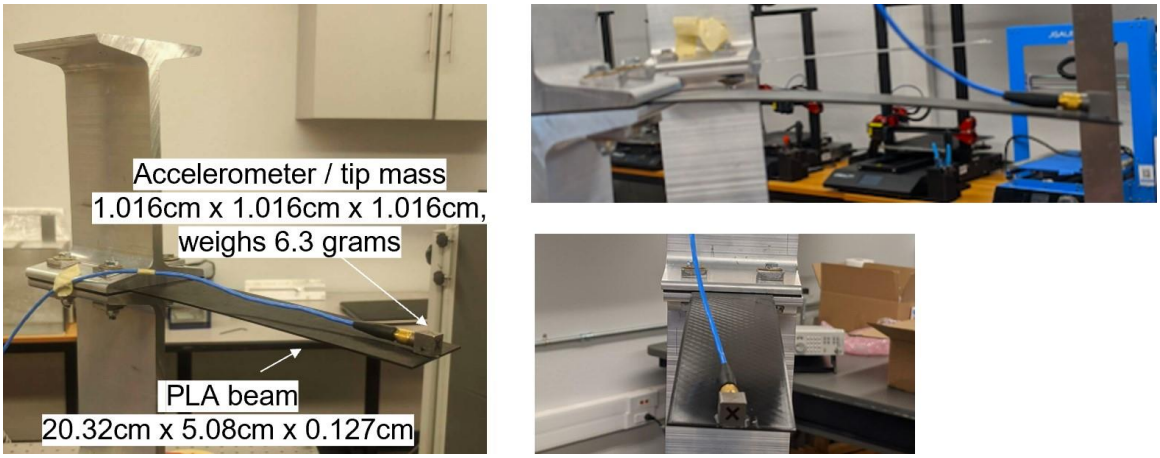

Figure 1: Experimental setup of PLA-based cantilever beam.

Results and discussion

The goal of this study is to fundamentally understand the physics of beam-based systems with additively manufactured materials using a controllable dynamical system. Although solutions have been proposed to analytically calculate the torsional modes of an orthotropic beam [3], the literature is missing information concerning the nonlinear behavior of additively-manufactured systems. Preliminary results show the frequency response of the additively-manufactured material is very complex. Deeper linear and nonlinear investigations will be performed experimentally to study the dynamical responses of AM beam systems.

References

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