JJCAB2014/21
Adaptive Damping Structure based on Shape Memory Polymer

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The shape memory polymers (SMP) are polymeric smart materials which have the remarkable ability to recover their primary shape from a temporary one under an external stimulus. The SMP encounter a growing interest over the past ten years particularly because their eventual bio-compatibility leads to many bio-medical applications. They also present many benefits for the design of micro-adaptive systems for deployment or controlled damping materials. This latter case is at the center of the work which is presented in this paper.

The chosen polymer is a chemically cross-linked thermoset. It is synthesized via photo polymerization (UV curing) of the monomer tert-butyl acrylate (tBA) with the crosslinking agent poly(ethylene glycol) dimethacrylate (PEGDMA) and the photoinitiator 2,2-dimethoxy-2-phenylacetophenone (DMPA). The mechanical characterization of this SMP was performed thanks to three kinds of tests: quasi-static tensile tests, dynamic mechanical analysis and modal tests. The promising damping properties depending on the frequency and the temperature are measured. This characterization of the viscoelastic properties of the SMP on a wideband of frequencies is necessary to develop a suitable model for the prediction of the vibration characteristics of this adaptive damping structure.

The principle of this structure is to distribute metal balls periodically, controlled in temperature, on a SMP matrix. The designed structure combines two effects to control wave propagation. The first one is the Bragg effect, corresponding to wave interferences in a frequency range which is related to the size of the periodicity of the pattern. The second one is the damping ability of the SMP which reaches very high loss factor values at glass transition. Indeed, by heating certain parts of the SMP matrix at selected temperatures, through metal balls, the time-temperature superposition allows tuning of the frequencies corresponding to optimal values of damping ratio. It is therefore possible to damp vibrations on a wideband of frequencies with a unique structure, which is adaptive. The damping capacities of this structure are illustrated through numerical simulations using multiphysics finite elements.

Number of words in abstract: 324
Keywords: Shape memory polymer - viscoelasticity - damping - smart structure
Technical area:
Special session: no reference to a structured session
Presentation: No preference
Special equipement: