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INFLUENCE OF THE STRUCTURAL NON-LINEARITY ON THE PERFORMANCE OF AN ELECTRET BASED VIBRATION ENERGY HARVESTER

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Summary: To enhance the performance of a miniaturized vibration energy harvester a film of electret material is currently proposed to cover the surface of one electrode to generate the required electric charge instead of an external generator. Some authors investigated the behavior of those capacitive harvesters by considering a vibrating cantilever beam equipped with a seismic mass at the tip. A simple model with a single degree of freedom was often used to predict both the structural and electromechanical behaviors. Usually the cantilever mass is neglected. Only few authors realized that several nonlinearities may occur, not only that associated to the electrostatic force, although they strongly affect the electromechanical coupling. In fact, in a bended cantilever beam rotation of cross section can be sufficiently large to change the local direction of electromechanical force applied by the electric field between electrodes. In a clamped-clamped beam surface of vibrating mass is kept almost parallel to the fixed electrode, but a geometric nonlinearity arises when a sufficient deformation is reached because a coupling between the axial and flexural behaviors of structure. In this case a stiffening of beam occurs as the load grows up. This effect can be exploited and therefore a goal of the work was investigating the effects of clamped-clamped configuration, of its nonlinearity on the dynamic behavior of the harvester, in terms of frequency range, performance and optimal parameters to be assigned to the electrets layer. Moreover, model of the electromechanical coupling was integrated with a discretized model of the beam connecting the mass to the clamps. It allowed monitoring suitably the coupling between axial load and bending, thus detecting some beneficial effect of nonlinearity, in case of a clamped-clamped configuration. Elastic clamps were considered. To perform the analysis of the energy conversion in the time domain, the model was developed in Matlab language instead of resorting to a commercial FEM code A comparison with some experimental results obtained in the literature was finally performed to define the improvements provided by the mechanically coupled configuration.