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BASELINE AEROELASTIC AND PERFORMANCE ANALYSIS OF PIEZO-AEROELASTIC SPACE-STRUCTURE FOR ENERGY HARVESTER

Abstract

The progress of energy harvesting technology and self-powered systems that has been prompted by the development of low power electronics offers autonomous systems that require minimum maintenance that are essential for their deployment in previously inaccessible locations. Energy Harvesting can be defined as the process of capturing energy, which are relatively minute, from the naturally occurring ("Green") energy sources, and then accumulating them and storing them for later use. Autonomous system and smart material technology that are now widely utilized take advantage of the thermal energy that can be converted to electrical energy by the Seebeck-Peltier effect, or mechanical energy extraction in piezoelectric system. These make extracting energy from mechanical energy an attractive approach for powering electronic systems, as in piezoelectric system. Piezo-aeroelastic energy harvesters convert airflow induced vibrations into electrical energy, while the availability and affordability of piezoelectric transducers offer a class of flapping foil energy harvesters mostly in micro- to milliwatts scale which need to be tuned to match the characteristic frequencies. The present work presents a brief review of aeroelastic instability of a generic typical wing section due to the free stream flow field which is utilized as an oscillating foil energy converter. For propaedeutic analysis a generic piezo-aeroelastic cantilevered beam is defined and treated as a typical section. The basic governing equation of this generic structure is treated as a three degrees of freedom electro-dynamic system, with the first two-degree-of freedom comprising the standard binary aeroelastic system with additional relevant terms to represent the influence of a piezoelectric embedded element on the cantilevered wing. Following the philosophical approach of binary aeroelastic system, the problem is mathematically formulated and solved for the range of solutions that can be obtained depending on the prevailing physical properties of the system, focusing on the stability characteristics of the generic system. The characteristic of the unsteady aerodynamics of the oscillating system associated with favorable energy harvesting capabilities are assessed.