Innovation in turbomachinery blade construction has led to significantly increased aerodynamic efficiency, in addition to reduced weight, drag, parts count, and complexity. There is, however, a cost associated with these advances — namely, greatly reduced structural damping and in turn large vibratory stresses. Over time, these stresses can cause a blade to succumb to high cycle fatigue, potentially leading to crack propagation and ultimately catastrophic failure. In light of these issues, a vibration reduction approach is desired to alleviate large vibratory stresses and thus increase blade lifetime. One such approach, resonance frequency detuning, is of particular interest here. Resonance frequency detuning uses piezoelectric materials to tailor a blade’s structural properties in an effort to avoid resonance conditions, thus limiting vibratory response. Implementation of this vibration reduction technique requires an on-blade power source to modify the electrical boundary conditions of the integrated piezoelectric material and thus alter the structural stiffness of the blade. Conveniently, the same piezoelectric material used for stiffness control can be used to harvest energy when the control system is not active. This work focuses on understanding the behavior of piezoelectric-based energy harvesting systems within the context of resonance frequency detuning. A metric is developed to study the relationship between harvested power and structural stiffness, and a key result is that appreciable energy can be harvested far from the usual optimal conditions in a typical energy harvesting approach. Indeed, sufficient energy is available to power the on-blade control while essentially maintaining the desired stiffness states for detuning. Furthermore, it is shown that the optimal switch in the control law for resonance frequency detuning may be triggered by a threshold harvested energy, requiring minimal on-blade processing.

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The public is welcome to attend.