Dissipation induced energy harvesting and its effect on flow-induced instabilities of piezoelectric energy harvesters

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When a slender beam or plate is placed in an axial flow, its straight equilibrium position can become unstable once a critical value of the flow velocity is reached. This phenomenon, called flutter instability, originates from a coupling by the flow of the structural modes. This instability is part of the family of structural instabilities subject to gyroscopic or nonconservative forces [2], which include follower force problems [1] or rotating machinery problems [3]. It has been shown that the addition of dissipation in such problems can be destabilizing. In other words, the system with dissipation becomes unstable at lower velocities than that with dissipation.
Such flow-induced instabilities, once triggered, transfer kinetic energy from a flow to mechanical energy. The use of piezoelectric coupling has been considered in order to convert the mechanical energy into electrical energy [4]. Energy extraction into useful electrical energy represents, from the point of view of the fluid-solid system, an additionnal dissipation. The later can also enhance the instability, like more conventionnal dissipation.
In this context, we will present stability analyses of plates covered by piezoelectric patches in axial flow. The stability of flexural waves in the infinite medium will be adressed as well as stability of modes of the finite length system. Cases of destabilization by dissipation due to energy harvesting will be shown. An energy harvesting efficiency analysis will be also presented. Among other results, this efficiency, defined as the ratio of the harvested energy to the mean energy present in the system, can be maximized when the instability has been triggered by the addition of energy harvesting.

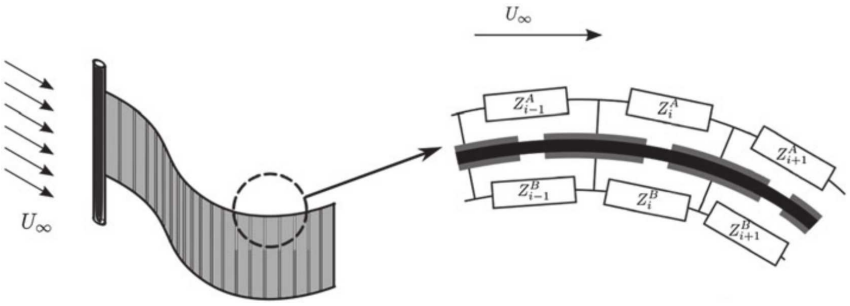

Figure 1: Plate covered by piezoelectric patches in an axial flow.

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