Parametric study of a fully-passive oscillating-foil turbine on a swinging arm

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ABSTRACT

Attached only with dampers and springs, a NACA 0015 airfoil connected to a lever arm is let loose in an incompressible and viscous flow. The foil, operating in a power extracting regime, is free to pitch about a pivot which is itself swinging on a circular path; this contraption is called a fully-passive swinging foil turbine. Its motion, driven by a net energy transfer from the stream, is resolved with a fluid-structure algorithm coupling Newtonian dynamics with two-dimensional unsteady Reynolds-averaged fluid simulation (URANS). This study explores the potential of four different foils configurations: with the swinging arm being either upstream or downstream of its pivot, and with or without the use of gears to control the resting position of the foil with respect to the flow. Such turbines could be used to construct flow harvesters which are significantly simpler, from a mechanical point of view, than fully-constrained oscillating foil turbines and still simpler than their fully-passive counterpart heaving on a rail. In this numerical study, the parameters for swinging turbines were deduced from the literature of fully-passive turbines on rails and the results show that the swinging turbine offers similar performance than that of the railed turbine. In fact, on a specific range of the arm’s length in the upstream position, the efficiency predicted is even greater than that of the optimized coupled-flutter railed model from the literature. As a matter of fact, with chord-based dimensionless lengths of 3 to 10, efficiencies near 54% are reached using similar structural parameters than those of previous works on the coupled-flutter railed turbine. Furthermore, it is found that geared models are the only ones suited for cases driven by a coupled-flutter instability with an arm’s length shorter than ten chords whilst both configurations could otherwise be used when the driven mechanism is a stall-flutter instability.