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Why do non-linear springs give higher energy extraction efficiencies during Vortex Induced Vibrations? RAMEEZ BADHURSHAH, RAJNEESH BHARDWAJ, Indian Institute of Technology Bombay, AMITABH BHATTACHARYA[1], IIndian Institute of Technology Delhi — Vortex Induced Vibrations (VIV) of a spring-mass system immersed in uniform fluid flow can be used for hydrokinetic energy generation. Several researchers have found that introducing non-linearity in the spring potential dramatically increases the range of reduced velocity over which structure synchronizes (locks in) with the vortex shedding, and also yields high energy extraction efficiency. To understand how spring non-linearity affects lock-in, a theory is formulated, in which the rate of energy generation via vortex shedding is balanced by the rate of energy dissipated via damping. The theory implies that a universal "Equilibrium Constraint" exists between oscillation amplitude and structure frequency. Lock-in occurs when the natural frequency versus amplitude curves intersect the EC curves. As a result, non-linearity in springs can widen the span of reduced velocity over which lock-in occurs. We find that the EC is dependent on the ratio of damping coefficient to reduced velocity, which in turn explains the higher energy extraction efficiencies seen in VIV-based hydrokinetic energy generators in the presence of non-linear springs. Numerical simulations, based on Immersed Boundary Method, have been used to validate the above theoretical analysis.

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