INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
PhD-17 SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

Vortex-induced vibration (VIV) of rigidly coupled circular and elliptical cylinders is numerically investigated using the finite-volume solver OpenFOAM to understand fluid–structure interaction mechanisms and assess their potential for hydrokinetic energy harvesting. The study focuses on tandem and staggered cylinder arrangements undergoing transverse oscillation at low Reynolds numbers and examines the effects of spacing, geometry, and structural parameters on vibration response, wake dynamics, synchronization, and power extraction.

For rigidly coupled circular cylinders, both tandem and staggered configurations are analysed over a range of streamwise and transverse spacings. Tandem arrangements generally exhibit larger vibration amplitudes and broader regions of significant response, while staggered arrangements display wider synchronization regions and more complex wake interactions. Distinct response branches and vortex shedding modes are identified, and the role of cylinder spacing in governing force, phase, and wake characteristics is examined. The downstream cylinder is found to significantly influence the overall system response.

The energy harvesting capability of the coupled-cylinder configurations is investigated by introducing structural damping and modelling the harvested power as the energy dissipated through a linear damper. Optimal spacing and damping conditions for maximizing extracted power, power density, and conversion efficiency are identified. Although tandem arrangements produce higher vibration amplitudes, appropriately selected staggered configurations provide superior overall harvesting performance.

The influence of body geometry is further explored using elliptical cylinders with varying aspect ratios. Elliptical cylinders exhibit enhanced vibration amplitudes, wider synchronization regions, and higher power output than circular cylinders, with an aspect ratio of 0.4 yielding the best performance. A two-degree-of-freedom elliptical-cylinder system undergoing coupled heaving and pitching motion is also investigated. The findings provide valuable insights into VIV-based energy harvesting and offer guidelines for the design of efficient hydrokinetic energy harvesters.