



MECHANICAL ENGINEERING PhD SEMINAR

Monday, December 15, 2025, at 14:30, D. Dan and Betty Kahn Building, Room 217

Flow field and structural dynamics of tethered spheres undergoing VIV

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The flow field in the wake of tethered spheres undergoing vortex-induced-vibrations (VIV) is highly complex and depends strongly on the reduced velocity, U^* , and mass ratio, m^* , amongst others. VIV can have disastrous results but can also be used to our advantage for example in the harvesting of green energy. The effects of U^* and m^* on VIV and understanding the mechanisms behind the onset of VIV are essential to gain a deeper understanding to optimize tethered structures. In this study, a combination of sphere tracking and tomographic particle image velocimetry (tomo-PIV) was used to measure the structural and flow dynamics of tethered spheres. The study was divided into three parts encompassing measurements at reduced velocity values ranging between $1.9 \leq U^* \leq 22.8$. In the first, the wake and sphere dynamics were measured as the tethered sphere crossed the first Hopf bifurcation (onset of VIV). Changes in the wake accompanying the onset of VIV indicated several well-defined stages associated with the changing instantaneous location of the velocity deficit centroid and the wake's symmetry plane's orientation. In the second part, the effect of a fourfold increase in mass ratio ($m^* = 1.7$ and 7.77) was investigated in the "lock-in" region where the vortex shedding frequency nearly matched the natural frequency of the tethered sphere. Combining two overlapping volumes of interest (VOI) allowed to resolve the flow field far downstream to study the evolution of the shed vortices in terms of their inclination, convection velocity, and forcing on the sphere. Results indicated that the shed hairpin vortices changed their orientation and evolved into vortex rings perpendicular to the mean flow direction. Their advection velocities increased until reaching plateau values further downstream. The vortex forces were slightly higher for the heavier sphere. In the last part, a method for analyzing complex, turbulent flows, based on calculating the curvature and torsion of the skeleton of the vortices in the flow field was proposed. The methodology was tested on the flow fields in the wake of the tethered spheres. The results indicate that this type of analysis may provide insights into characterizing the topology of vortical structures in turbulent flows. The findings of this research have improved the basic understanding of VIV of tethered spheres and provide a foundation for refined numerical modeling and flow-induced vibration control methods.

Note: the seminar will be given in English