A Proper Orthogonal Decomposition based
Reduced Order Model for Vortex-Induced Vibrations

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Research Objective

- Flow passing by a cylinder induces shedding vortices (shown below), leading to “vortex-induced vibrations.”
- If the cylinder is forced to oscillate, the shedding frequency and the oscillation frequency may lock in. Large-amplitude oscillations develop and induce fatigue and eventually, structural failure.
- Example of frequency lock-in: offshore platforms (water flowing over a pipe), turbomachinery (aerodynamic instabilities in jet engine compressors), and airplane-wing performance without running computationally expensive CFD simulations.

OBJECTIVE: Building a reduced-order model to predict locked-in solutions without running computationally expensive CFD simulations.

Method

- GOAL: Using locked-in solutions from a Harmonic Balance (HB) computational fluid dynamics (CFD) code to build a reduced-order model based on proper orthogonal decomposition (POD) techniques.

Visualization of the flow around the oscillating cylinder:
- The main features of the flow are well described using only two POD modes.
- Six POD modes are necessary to capture smaller details.

Conclusions and Future Work

- This research presents a novel way of accurately predicting locked-in CFD solutions with a reduced-order model to help prevent the failure of structures.
- Converged, locked-in CFD solutions from a HB algorithm can be used as basis functions (or snapshots) to form the POD modes of the reduced-order model.
- With the right choice of CFD snapshots, accurate CFD solutions may be predicted using a very small number of POD modes (fewer than six).
- CFD solutions are successfully predicted for a cylinder as well as for 2D and 3D compressor blades.
- The reduced-order model will be extended to other turbomachinery applications.

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References: