Objectives and Challenges for High Mode Number, Flow-induced Vibration, Model Tests in Sheared Flow

By Prof. J. Kim Vandiver
Massachusetts Institute of Technology
Cambridge, Massachusetts
kimv@mit.edu

Abstract

Response prediction of the vortex-induced vibration of uniform cylinders in uniform flow is pretty well understood. Recent super-critical Reynolds number tests on short, spring-mounted, rigid cylinders have addressed one of the major areas of uncertainty. However, response prediction in sheared flow is still too often a shot in the dark. There are many competing influences, which might affect the actual response. For example, shear steepness, modal spacing, and hydrodynamic damping will influence the final response. The circumstances under which single frequency dominance occurs is also very difficult to predict. So too is the actual mode number, which dominates the response. Additional data is needed from well-designed model tests to address some of these problems.

There are multiple initiatives under way to gather experimental data on long flexible cylinders, capable of exhibiting high mode number response. These data need to be useful in calibrating prediction programs. This paper outlines the principal problems that need to be solved. The ultimate objective is to be able to accurately predict fatigue damage rate on a long cylinder in sheared flow. To do this requires knowledge of the response statistics describing curvature and upcrossing rate. Unfortunately, high mode numbers require instrumentation with a high spatial density, which drives up cost and measurement complexity. Another problem is that sheared flow results in significant hydrodynamic damping which in turn diminishes reverberant standing wave behavior and often results in significant propagating wave behavior. Conventional, modal analysis, signal processing techniques become inappropriate.

The design of the experimental apparatus also has it's challenges. Realistic sheared flows are hard to create and control. Conducting a tow in a real ocean current such as the loop current or the Gulf Stream is expensive due to the logistics. Towing experiments have special challenges associated with bottom weights, total drag force, control of dynamic tension and associated vessel motion problems. On a long test cylinder the control of the orientation of individual sensors, such as strain gages or accelerometers becomes very problematic. It is appropriate to ask at what length and mode number, do measurements of separated in-line and cross-flow motion components cease to matter. These and other questions will be considered in the presentation.