An Investigation of the Flow along and Induced Vibration of Long Cylinders

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Abstract

An investigation of the interaction between the vibration of a cable towed under water and the flow developing in the vicinity of a slender cylindrical structure in axial flow, and departing from axial flow, is presented.

The modal characteristics of a towed cable are discussed and mode shapes for the motion of a neutrally buoyant cable towed in a viscous fluid are determined. The flow past static cylindrical structures, with shapes representative of the mode shapes identified, is then observed in flow visualisation experiments. More specifically, the structures forming in the flow past circular cross-section cylinders in axial flow and near-axial flow, and past cylinders featuring a sudden departure from axial flow are investigated. The turbulent boundary layer that forms on cylinders in axial flow essentially retains its identity when the cylinder is slightly yawed. The boundary layer thickness may grow to many cylinder radii, and large eddies of scales that exceed the cylinder radius are observed. When the cylinder in axial flow features a bend, and thus suddenly departs from being in axial flow, dominant streamwise structures are formed in the wake of the inclined portion of the cylinder. The formation of these structures generates a shear layer at the interface with the free stream flow, in which instabilities are found to develop.

Attention is concentrated on the characteristics of the surface-pressure field beneath turbulent boundary layers with thicknesses more than ten times the cylinder radius that form on cylinders in axial and near-axial flow. The investigation ranges over axial flow; flows with small angles of yaw (up to 1°), which produce distorted but still-recognisable boundary layers; and flows at yaw angles (up to 9°) that are sufficiently large for the boundary-layer flow to give way to oblique vortex shedding from the cylinder. It is concluded that the surface-pressure power spectra of axisymmetric boundary layers are consistent with the distinct frequency regimes which characterise the spectra of planar boundary layers, although the low-frequency regime may be more extensive; and that, despite the gross asymmetries in the outer regions of the boundary layer produced by small yaw angles, the scale of the main pressure-producing region of the layer changes very little with yaw angle.

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