Observability Conditions for POD Modes in a Circular Cylinder Wake

In a two-dimensional cylinder wake, self-excited oscillations in the form of periodic shedding of vortices are observed above a critical Reynolds number of around 50. These flow-induced non-linear oscillations lead to some undesirable effects associated with unsteady pressures such as fluid-structure interactions. The only way of suppressing the self-excited flow oscillations is by the incorporation of active closed-loop flow control. In order to enable the use of a control scheme based on a low dimensional, proper orthogonal decomposition (POD) model, it is necessary to detect and distinguish the POD modes. Based on two dimensional experimental data at Re = 125 from Particle Image Velocimetry (PIV) measurements of the entire wake flow, a POD model of the flow was developed. After selecting a small number of sensor locations, an estimator for the POD modes was designed using linear stochastic estimation. Using the sensor information, the estimator determines the amplitudes of the POD modes. Necessary conditions for the observability of the POD modes are derived. It is then shown that all four POD modes on which the model is based are observable for the given sensor setup. In order to estimate the first four POD modes, at least five sensors need to be positioned in the wake. For a smaller number of sensors, the necessary conditions for observability could not be met.