Surface and Wake Pressure Fluctuations of a Cylinder in Transitional Flow Regime

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Keywords: Pressure from PIV, Bluff Body Aerodynamics

HIGHLIGHTS

- Flow development in the turbulent wake of a circular cylinder for $Re = 0.6 \times 10^4 - 1.2 \times 10^4$ is investigated.
- Planar, Time-Resolved Particle Image Velocimetry (TR-PIV) measurements, with simultaneous surface microphone measurements are analyzed.
- Pressure estimations from the TR-PIV measurements are obtained from the solution of the Poisson equation.
- Modulations in fluctuating surface pressures are investigated and linked to near wake flow development.

ABSTRACT

Flow around a circular cylinder is investigated experimentally for $0.6 \times 10^4 \leq Re \leq 1.2 \times 10^4$. Simultaneous time-resolved surface pressure measurements and planar Time-Resolved Particle Image Velocimetry (TR-PIV) measurements allow elucidation of the relationship between the spatio-temporal flow development and trends in the surface pressure fluctuations. Pressure field estimations from the PIV measurements reveal the pressure field topology in the near wake and facilitate the quantification of the contribution of the von Karman and Kelvin Helmholtz vortex structures to the pressure fluctuations in the wake and at the surface. The results provide insight into the flow physics responsible for the significant changes in structural loadings observed within the studied range of Reynolds numbers. For $Re = 0.6 \times 10^4$, significant cycle-to-cycle modulations are identified in surface pressure fluctuations and are linked to temporal variations in the vortex formation length. With increasing the Reynolds number above this critical value, the modulations are reduced and the significant reduction of the vortex formation length leads to a significant increase in surface pressure fluctuations and, hence, structural loading.

Fig. 1 Modulations in surface pressure fluctuations measured at $Re = 0.6 \times 10^4$ with time sequences of spanwise vorticity (left to right increasing time) associated with lower (red) and higher (blue) amplitude surface pressure fluctuations.