PRESSURE EVALUATION FROM VELOCITY MEASUREMENTS

APPLICATION NOTE PIV-022 (A4)

In fluid mechanics applications, combining both the pressure and velocity fields gives a complete description of the flow dynamics. The pressure field in a fluid is the main contributor to the aerodynamic loading of bodies immersed in the fluid so determining it is of great interest in both fluid mechanics and engineering. The benefit of Particle Image Velocimetry (PIV) is that it is a non-intrusive measurement method providing high spatial resolution which is unavailable when using pressure transducers.

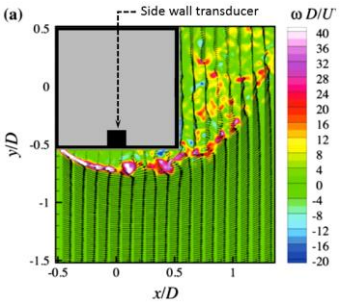
The operating principle of obtaining instantaneous pressure fields from instantaneous PIV velocity fields consists of solving the incompressible momentum equation (1) using a Poisson solver while considering a reference pressure and Neumann boundary conditions in the measurement domain (Kat & Oudheusden, 2012):

$$\nabla p = -\rho\left\{\frac{\partial u}{\partial t} + (u.\nabla)u - \nu\nabla^2 u\right\} \qquad (1)$$

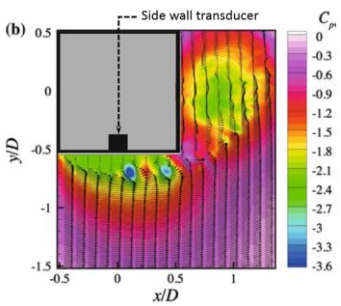
Some rules-of-thumb need to be considered in order to correctly capture the instantaneous pressure from PIV:

- The interrogation window size needs to be at least 5 times smaller with respect to the flow structures.
- The acquisition frequency needs to be 10 times higher than the frequency in the flow.
- In 3D flows, all components of velocity and velocity gradients are needed which may be acquired through the use of the V3V™ volumetric PIV technique.

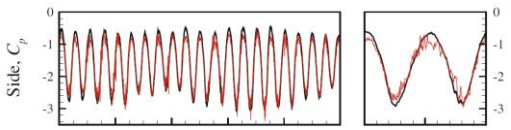
An example of the vorticity and pressure fields measured using SPIV around a square section body is shown in figures (a) and (b) below. The pressure signal derived from the velocity shows good agreement with the signal measured using a pressure transducer (c):



(a) Vorticity field



(b) Pressure field



(c) Pressure signal from stereo-PIV (red) vs Transducers (black)

Reference

R. de Kat • B. W. van Oudheusden, Instantaneous planar pressure determination from PIV in turbulent flow, *Exp Fluids* (2012) **52**:1089–1106.

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PIV-022 Rev. B (3/10/2021) A4 Printed in U.S.A.