

Large scale particle image velocimetry of natural and mixed convection

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Application of Particle Image Velocimetry to measurement of flows on large scales is a challenging necessity especially for investigation of convective air flows. By combination of helium filled soap bubbles as tracer particles with high power quality switched solid state lasers as light sources stereoscopic Particle Image Velocimetry on scales as large as 12.6 m² has been made possible. An indispensable requirement for such measurements, however, is a bubble generator with high generation efficiency. Therefore a three channel bubble generator operating orifice nozzles and providing several thousand bubbles per second was built. The technique was applied to mixed convection in a full scale double aisle aircraft cabin mock-up for validation of computational fluid dynamic techniques and to natural convection in a large scale Rayleigh-Bénard facility for detection of characteristic convection patterns.

First, as an example for measurement of large scale air flows in compartments, PIV of mixed convection in a full scale aircraft cabin mock-up at the German Aerospace Centre in Göttingen is discussed. The mock-up is a generic replica of an A380 upper deck and equipped with 40 passenger dummies, which serve as obstacles and provide the natural heat load. Figure 1 depicts the average velocity map for an air-exchange rate of 23/hour under cooling conditions as measured by PIV. In the cooling case the temperature of the

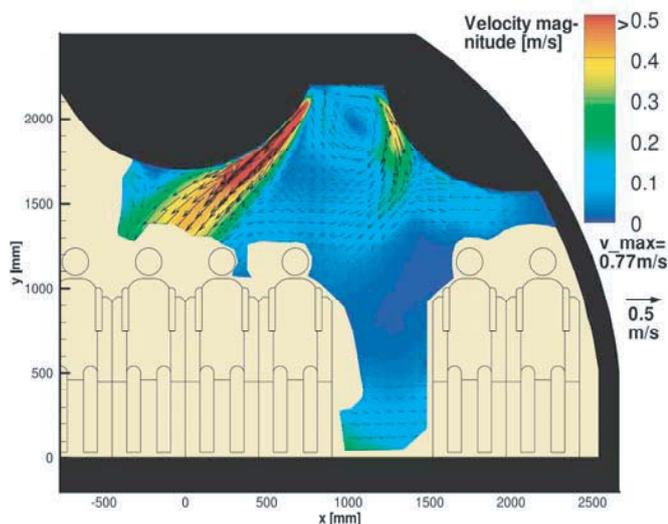


Fig. 1 Air flow in the A380 air craft cabin mock-up studied with large-scale 2C-2D PIV under cooling conditions. The temperature difference between cabin air and incoming air amounts to 6 K. The plot depicts the average in-plane velocity map as determined from 360 instantaneous velocity fields.

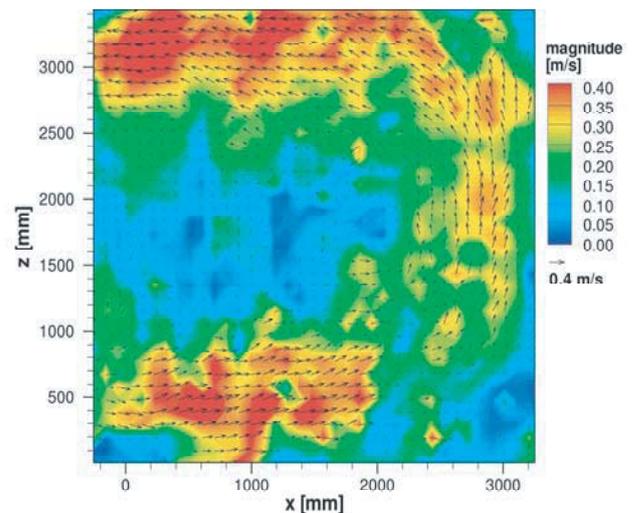


Fig. 2 Instantaneous velocity map of a single convection roll in the Barrel of Ilmenau measured with large-scale 3C-2D PIV. One half of the cell was investigated at aspect ratio 2.

cabin air is 6 K higher than the temperature of the incoming air. The resulting velocity maps are of utmost importance for judging on the thermal comfort of the passengers and for further improvements of the cabin layout.

As a second example, stereoscopic PIV of natural convection in a large-scale Rayleigh-Bénard experiment is discussed. The measurements were conducted in the Barrel of Ilmenau, which is constituted of a cylindrical container with an inner diameter of $D = 7.15$ m and a variable height H of $0 \text{ m} < H < 6.3$ m. As a fluid, ambient air is used. Figure 2 depicts an instantaneous velocity map in one half of the Barrel of Ilmenau. The measurement was conducted at an aspect ratio of $D/H = 2.0$, where a transition of a steady two dimensional mean flow structure into three dimensional structures is expected to occur. Clearly in Figure 2 a single large roll structure can be recognized, while more complex structures have been detected in further velocity maps as well.