Large-Field Measurement of Fan Heater Jets using Particle Image Velocimetry and Background-Oriented Schlieren

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HIGHLIGHTS

• Large-field PIV and BOS were used to measure buoyant jets from a fan heater over ~2 x 1 m²
• The BOS used a background pattern based on a unipolar maximum length sequence to reduce noise
• Time-averaged PIV validation using isothermal turbulent round jets agreed to prior studies within ±2.5%
• The hot jet trajectory shows good agreement with horizontal buoyant jets from round sources, but with virtual origin shifted upstream
• The source Froude number is identified as the key governing parameter for these buoyant jet flows

ABSTRACT

Techniques for measuring buoyant jet flows over large areas have been developed using Particle Image Velocimetry (PIV) and Background-Oriented Schlieren (BOS) with a Dyson AM09 fan heater. PIV was performed along the jet centreline using two side-by-side 5.5 megapixel cameras acquiring simultaneously at 15 Hz with a 200 mJ Nd:YAG laser. This setup was validated against a high-Reynolds-number isothermal turbulent round jet, showing excellent agreement to previously published works. The BOS technique was developed in-house using a single 24 megapixel DSLR, with specially designed background pattern based on a unipolar maximum length sequence. These techniques allowed measurement over 1.71 x 0.73 m² and 1.95 x 1.30 m² for PIV and BOS, respectively, both with resolution of less than 5.5 mm. These techniques proved extremely useful in studying these buoyant jet flows, where more traditional techniques like hot-wire anemometry and Pitot probes would be prohibitively difficult due to the high level of turbulence, regions of reversing flows at the jet edges plus the fluctuating temperature field, let alone the challenges due to the size of the measurement area required to achieve useful information at human scale. Accurate alignment was critical to both techniques, where much care was necessary when setting the cameras. Our experiments showed that the buoyant jet agreed well with universal flow envelopes from horizontal buoyant jets from circular sources when scaled with the source Froude number (white/black lines in Fig. 1, below), albeit with virtual origin shifted upstream. We also compare with other fan heaters with quite different source Froude numbers.