LDV MEASUREMENTS OF THE CENTERLINE VELOCITY PROFILE OF A ROUND JET

APPLICATION NOTE LDV-011 (A4)

Laser Doppler Velocimetry

Laser Doppler Velocimetry is an optical technique in which the light scattered from tracer particles within a flow of interest and passing through a laser beam crossing is analyzed in order to determine the flow velocity. In this experiment, particles introduced into a round jet with Reynolds number of 36,000 were illuminated and the velocity extracted through the use of a TSI® LDV system and FSA 5800 photo detector and signal processor.

Figure 1. FSA 5800 Photo Detector and Signal Processor.

Experimental Setup

An FSA 5800 photo detector and signal processor unit was used to take Laser Doppler Velocimetry (LDV) measurements in air on a jet with a d = 6 mm round exit and nominal centerline velocity of 90 m/s. The TR160 transmitter was traversed across the nozzle exit at 1 mm intervals in order to map out the velocity profile at a distance of one diameter from the exit. The flow was seeded with olive oil droplets generated from a 9307-6 Laskin nozzle aerosol generator which produces seed particles on the order of 1 micron in diameter. The seeding was introduced through the pressure port located before the contraction region of a Model 1128B Hot-Wire Calibrator.

A photo of the experimental setup can be seen in Figure 2.

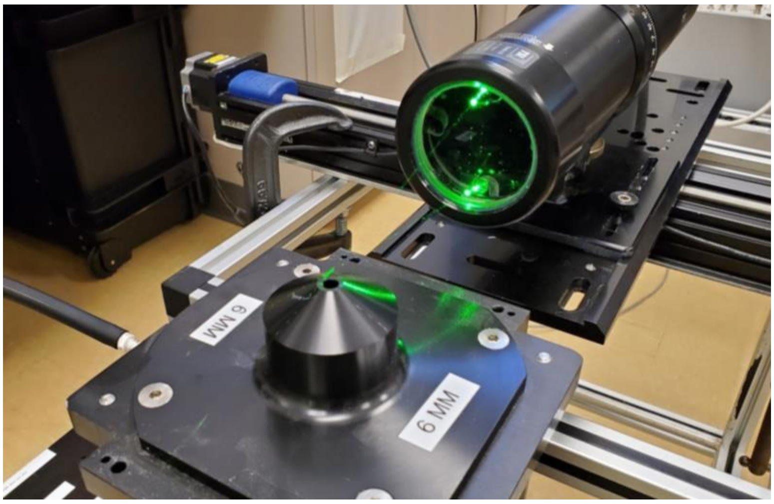

Figure 2. Experimental setup showing the transmitted beams intersecting at one diameter above the nozzle exit.

Results

The peak velocity at the center of the jet was 89.23 m/s. A traverse scan of 9 mm (±4.5 mm from the centerline of the jet) were taken at 1 mm intervals at a distance of 1 diameter from the jet exit.

A computational fluid dynamics (CFD) simulation was also carried out on an identical flow. The calculation volume was a cube of length 400 mm, width of 400 mm, and height of 300 mm. A k-epsilon model was used. A planar slice of the volume can be seen in Figure 3, and the velocity profile one diameter downstream of the jet exit was extracted for comparison to the LDV results.

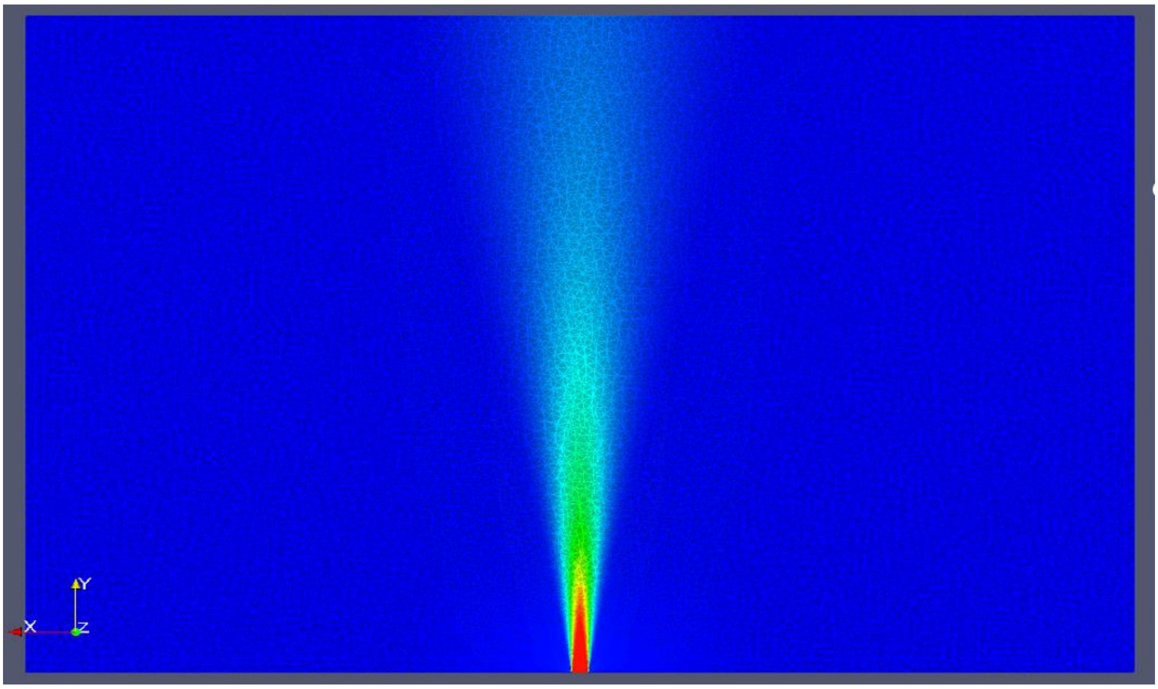

Figure 3. Computational domain showing the centerline velocity of the jet.

The normalized results of the velocity measurements can be seen in Figure 4. The solid circles represent the current measurement carried out with the LDV system (bars represent the velocity RMS). The dashed line represents the results from the simulation. The experimental and simulated results show very close agreement.

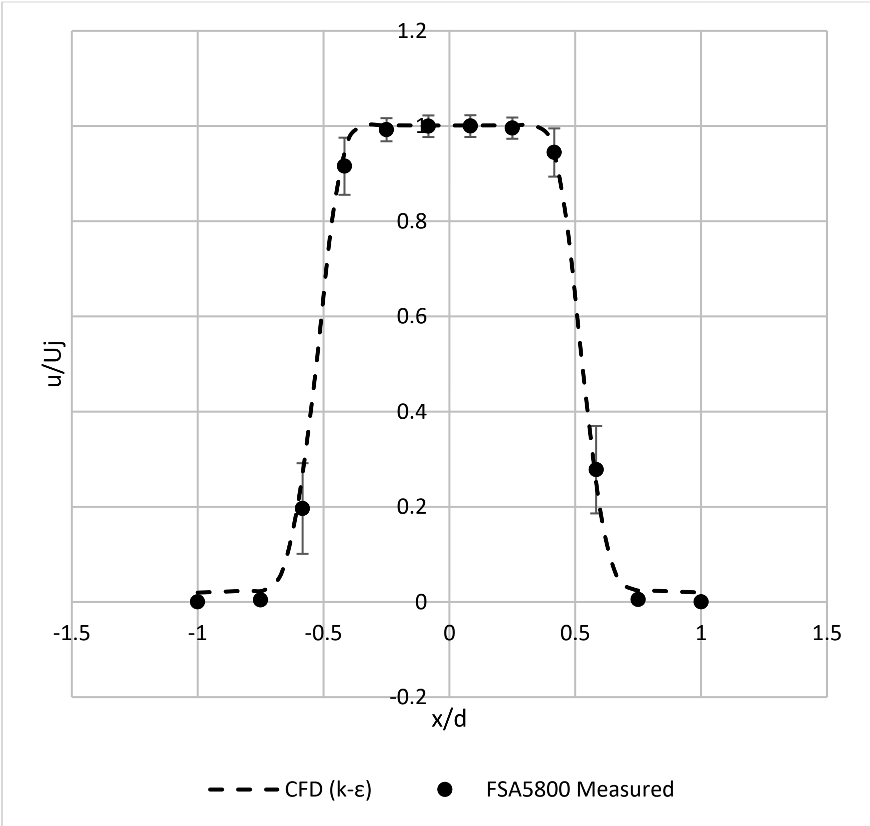

Figure 4. Velocity profile of the jet at one diameter downstream of the exit. A comparison between the current LDV measurements (black circles) and CFD results (dashed line).

Figure 5 displays the results of the current study in relation to several other measurement techniques, namely, particle image velocimetry (PIV) and Hotwire Anemometry. The current measurements are represented by solid circles (bars represent the velocity RMS), the figure also includes results from similar experimental setups and Reynolds numbers for PIV (Ghasemi et al, 2013) and hot-wire anemometry (Li & Ming, 2016).

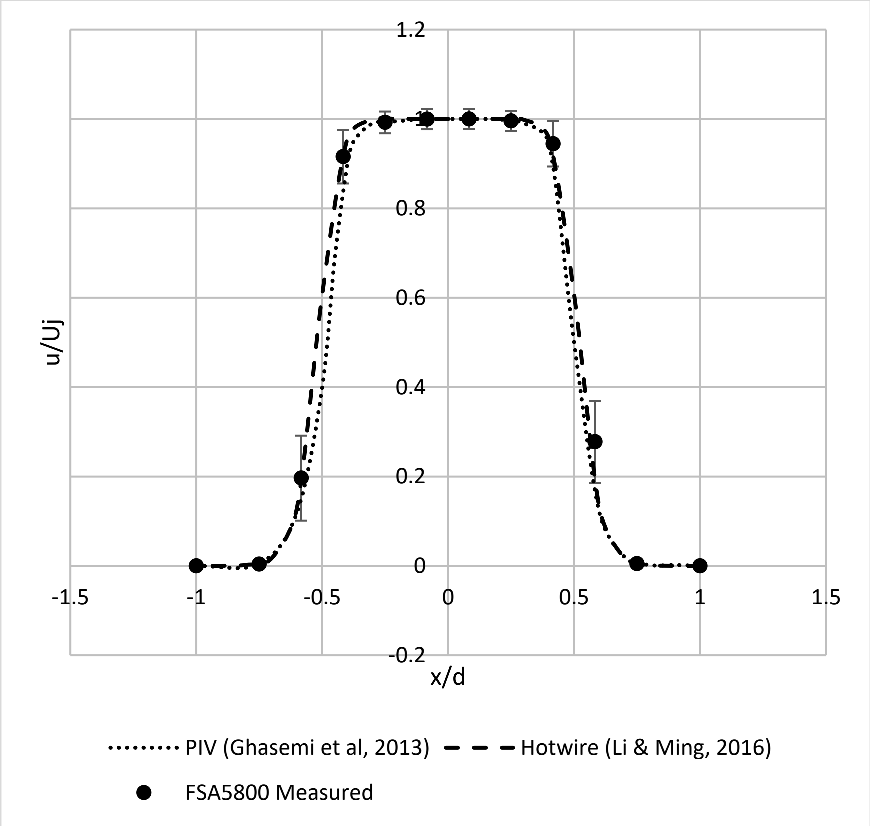

Figure 5. Velocity profile of the jet at one diameter downstream of the exit. A comparison between the current results (solid circles), PIV (dotted line), and Hotwire Anemometry (dashed line).

The jet velocity profile along the centerline of the round jet matches very well with the results from similar experiments using PIV and hot-wire anemometry.

Conclusion

A TSI® LDV system consisting of a TR160 transmitter and an FSA 5800 photo detector and signal processor was used to measure the velocity profile of a round jet at one diameter. The peak velocity along the centerline of the jet was 89.23 m/s.

The measurements were compared to a k-epsilon simulation as well as with previously acquired data from other experimental techniques including PIV and hot-wire anemometry. The measurements matched well and displayed a very high degree of repeatability.

The FSA 5800 measured accurate results with very low noise.

References

Ghasemi, A., Roussinova, V., Barron, R., & Balachandar, R. (2013). "Analysis of entrainment at the turbulent/non-turbulent interface of a square jet." *ASME International Mechanical Engineering Congress and Exposition, Proceedings (IMECE)*, **7A** (July 2014). https://doi.org/10.1115/IMECE2013-65355

Li, Y., & Ming, X. (2016). "Oscillations of a planar impinging jet induced by a potential-core confined airfoil." *European Journal of Mechanics, B/Fluids*, **57**(November), 40–49. https://doi.org/10.1016/j.euromechflu.2016.02.007

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