Comparison of Simultaneous PIV and Hydroxyl Tagging Velocimetry in Low Velocity Flows

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HIGHLIGHTS

- Hydroxyl tagging velocimetry (HTV) is applied to low-speed flows by increasing tracer lifetime using an inert gas and moderate temperature increase.
- The goal is to be able to measure long-duration flow transients, where tracer settling is an issue for particle-based diagnostics.
- HTV setup is composed of excimer laser (193 nm) for generating a tag line and a dual-pulsed dye laser (281 nm) for interrogating the data plane. Data are recorded with a CCD/intensifier/UV lens system.
- Laminar ($U_\infty =3.31$ m/s, $Re=1,540$), transitional ($U_\infty =4.48$ m/s, $Re=2,039$), and turbulent ($U_\infty =6.91$ m/s, $Re=3,016$) jets (N, at ~75°C) are probed with a dt of 250 µs.
- PIV is performed simultaneously using the dye laser pulse to illuminate droplets seeding the flow. Scattered UV light is collected with a second intensified camera.
- PIV and HTV data agree within 10% for single shot profiles and within 2 to 5% on mean profiles.

ABSTRACT

Hydroxyl tagging velocimetry (HTV) is a molecular tagging velocimetry (MTV) technique that relies on the photo-dissociation of water vapor into OH radicals and their subsequent tracking using laser-induced fluorescence. At ambient temperature in air, the OH species lifetime is about 50 µs. The feasibility of using HTV for probing low-speed flows (a few m/s) is investigated by using an inert, heated gas as a means to increase the OH species lifetime. Unlike particle-based techniques, MTV does not suffer from tracer settling, which is particularly problematic at low speeds. Furthermore, the flow needs to be seeded with only a small mole fraction of water vapor, making it safer for both the user and facilities than other MTV techniques based on corrosive or toxic chemical tracers.

HTV is demonstrated on a steam-seeded nitrogen jet at approximately 75 °C in the laminar ($U_\infty =3.31$ m/s, $Re=1,540$), transitional ($U_\infty =4.48$ m/s, $Re=2,039$), and turbulent ($U_\infty =6.91$ m/s, $Re=3,016$) regimes at atmospheric pressure. The measured velocity profiles are compared with particle image velocimetry (PIV) measurements performed simultaneously with a second imager. Seeding for the PIV is achieved by introducing micron-sized water droplets into the flow with the steam; the same laser sheet is used for PIV and HTV to guarantee spatial and temporal overlap of the data. Optimizing each of these methods, however, requires conflicting operating conditions: higher temperatures benefit the HTV signals but reduce the available seed density for the PIV through evaporation. Nevertheless, data are found to agree within 10% for the instantaneous velocity profiles and within 5% for the mean profiles and demonstrate the feasibility of HTV for low-speed flows at moderate to high temperatures.