**Quantitative Visualization of Complex Thermal Fluid Phenomena by Using Advanced Flow Diagnostic Techniques**



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**Abstract**

The talk will start with the description of the recent progress made by the speaker in developing a novel molecule-based flow diagnostic technique, named as Molecular Tagging Velocimetry and Thermometry (MTV&T), for simultaneous measurements of flow velocity and temperature distributions in fluid flows. Unlike most commonly-used particle-based flow diagnostic techniques such as Particle Image Velocimetry (PIV), MTV&T utilizes specially-designed phosphorescent molecules, which can be turned into long-lasting glowing marks upon excitation by photons of appropriate wavelength, as tracers for both flow velocity and temperature measurements. The unique glamour of the MTV&T technique will be demonstrated from the application examples to study the thermal effects on the wake instabilities behind a heated cylinder, visualization of the unsteady heat transfer and phase changing process within micro-sized icing water droplets, and transient surface water transport processes pertinent to aircraft or wind turbine icing and de-/anti- icing applications.

The second part of the talk will introduce the speaker’s recent research on wind turbine aeromechanics and wake interferences. The experimental studies are conducted in a large-scale Aerodynamic/Atmospheric Boundary Layer (AABL) Wind Tunnel. An array of scaled Horizontal Axial Wind Turbine (HAWT) models are placed in atmospheric boundary layer winds with different mean and turbulence characteristics to simulate the situations in onshore and offshore wind farms. The effects of the relative rotation directions of downstream turbines with respect to the upstream turbines, array spacing and layout, and the terrain topology of wind farms on the turbine performances and the wake interferences are investigated in detail. In addition to measuring dynamic wind loads (both forces and moments) and the power outputs of the HAWT models, a high-resolution Particle Image Velocity (PIV) system is used to conduct detailed flow field measurements to quantify the characteristics of the turbulent wake vortex flows and the wake interferences among the HAWTs. The detailed flow field measurements are correlated with the dynamic wind loads and power output measurements to elucidate underlying physics in order to gain further insight into the characteristics of the dynamic wind loads and wake interferences among multiple wind turbines for higher total power yield and better durability of the wind turbines in atmospheric boundary layer (ABL) winds.

**Keywords:** Molecular Tagging Velocimetry and Thermometry (MTV&T) technique, multiphase flow and phased changing flows, aircraft icing, wind turbine aeromechanics and wake interferences.Top of Form