Development of Advanced Flow Diagnostic Techniques to Characterize Complex Multiphase Flows

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Abstract: Aircraft icing phenomena involve in complicated interactions among multiphase flows (i.e., gaseous incoming airflow, super-cooled liquid water droplets/surface water film flows, and ice accreting solid airfoil surface) coupled with unsteady heat transfer (i.e., the release of the latent heat of fusion) and dynamic phase changing (i.e., solidification) processes. The research progress made in the speaker's laboratory in developing novel flow diagnostic techniques to characterize the complex multiphase flows pertinent to aircraft icing phenomena is presented. A novel molecular tagging technique is introduced at first to achieve simultaneous measurements of droplet size, flying velocity and transient temperature of in-flight liquid droplets, which is pertinent to the dynamic and thermodynamic behaviors of flying super-cooled droplets before impacting onto airfoil surfaces to start ice accretion process. Then, a novel digital image projection (DIP) technique is also introduced to achieve quantitative measurements of the droplet/film thickness distributions to quantify the dynamic impact process of droplets onto solid surface with different impact velocities and surface wettability. Based on the time-resolved DIP measurements, the time evolution of the droplet shapes in the course of the dynamic impact process, i.e., the spreading, receding, and oscillating of the impinging droplets, under different test conditions are revealed clearly and quantitatively. The quantitative measurements are very helpful to elucidate the underlying physics for better understanding of the important micro-physical processes pertinent aircraft icing phenomena in order to develop more effective and robust anti-/de-icing strategies to ensure safer and more efficient aircraft operation in cold weather.

Short-biography: Dr. Hui Hu is the Martin C. Jischke Professor and Associate Dept. Chair of Aerospace Engineering at Iowa State University. Dr. Hu received his BS and MS degrees in Aerospace Engineering from Beijing University of Aeronautics and Astronautics (BUAA) in China, and a PhD degree in Mechanical Engineering from the University of Tokyo in Japan. Dr. Hu is an ASME Fellow and AIAA Associate Fellow. His recent research interests include laser-based advanced flow diagnostics; aircraft icing physics and anti-icing/de-icing technology; liquid fuel atomization and spray flow characterization; film cooling and thermal management of gas turbines; wind turbine aerodynamics and rotorcraft aeromechanics; bio-inspired aerodynamics; micro-flows and micro-scale heat transfer in microfluidics or "Lab-on-a-Chip" devices. Dr. Hu received several prestigious awards in recent years, including *2006 NSF-CAREER Award*, *2007 Best Paper in Fluid Mechanics Award (Measurement Science and Technology, IOP Publishing)*, *2009 AIAA Best Paper Award in Applied Aerodynamics*, *2012 Mid-Career Achievement in Research Award* of Iowa State University, *2013 AIAA Best Paper Award in Ground Testing Technology, and 2014 Renewable Energy Impact Award of Iowa Energy Center*. Further information about Dr. Hu's technical background and recent research activities is available at: http://www.aere.iastate.edu/~huhui/