“Closed-Loop Flow Control as an Enabler for Next Generation Aerospace and Energy Systems”

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Abstract

In this talk I will present a snapshot of our ongoing research that integrates ``intelligent systems and controls'' concepts and tools into our attempts to better understand and control fluids systems dominated by unsteady aerodynamics and turbulence. Our specific applications come from the Aerospace and Energy sectors and include; reduction of adverse aero-optics effects due to compressible turbulence around aircraft turrets, noise reduction from high speed jet aircraft and, reduced unsteady loads and noise and improved aero efficiency on scaled wind turbine blades. The turret research has been performed jointly with Clear Science Corp. under Air Force support (see two recent papers in AIAA Journal, August and September 2012) and involves closing the loop on time scales of the moving geometry, i.e., the dynamically articulating turret. These results clearly show the advantages of closing the loop for aero-optic distortion reduction, rather than relying on active open loop or passive flow control methods. The high speed jet work (Mach 0.6 – 1.2) has been jointly performed with Spectral Energies LLC. through Air Force support and researchers from Poitiers France and involves 10 kHz PIV data extracted from the near field jet plume, simultaneously sampled with near field pressure and far field noise, both with and without control. Open-loop and pressure based closed-loop flow control have been applied with actuation at the lip of the jet at time scales in the same bandwidth as relevant flow time scales. Only the close-loop control was able to reduce the far field noise and all the open loop cases we surveyed increased the far field noise. We have learned from the simultaneously sampled 10 kHz PIV near field plume and far field noise data, using POD and Wavelet filtering, that there are certain ``loud'' velocity modes that have low turbulent kinetic energy content but strongly correlate with the far field noise. These recent results are currently being used to develop an ``intelligent'' POD based controller and the status of these ongoing experiments will be discussed. Finally I will conclude with a description of our joint research with the University of Minnesota DoE funded Wind Energy Consortium on closed-loop flow control for reducing unsteady loads and noise and, improving aerodynamic efficiency on scaled wind turbine blades. The results that I will present indicate that even with a relatively simple proportional closed-loop surface pressure based control we are able to reduce the RMS loadings induced by large scale flow unsteadiness (shedding vortices from an upstream cylinder) consistently by more than 12 %.

Biographical sketch

Glauser is Associate Dean for Research and Doctoral Programs and Professor of Mechanical and Aerospace Engineering in the LC Smith College of Engineering and Computer Science and Professor of Physics in the College of Arts and Sciences at Syracuse University. He is responsible for overseeing the LC Smith College's current research activities and coordinating the development of its future research portfolio. Glauser's own research includes developing flow control methods for improving efficiency and reducing noise on large wind turbines and noise reduction/enhanced mixing for high speed turbulent jets. He has obtained more than 10 Million dollars in research funds, published 100+ peer-reviewed publications/proceedings and presented 100+ invited presentations and keynote talks worldwide. Glauser has mentored several post docs and 30+ Ph.D. and MS students. He was Program Manager for the Turbulence and Internal Flows Program at the US Air Force Office of Scientific Research from 1996-99 and is currently serving on the Army Science Board. Glauser is a Fellow of AIAA, ASME, APS and the Institute of Physics (UK). He received his BS Mechanical Engineering in1982 and his Ph.D. in 1987, both from the Department of Mechanical and Aerospace Engineering at the University at Buffalo/SUNY.