MECHENGINEERING SEMINAR

Mechanical Engineering Faculty Mini-Talks

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Experimental and Theoretical Analysis of Wind Energy: From Single Turbine to Wind Farm by Dr. Yaqing Jin

Wind is a mainstream source of electricity, and will play a leading role in achieving climate goals. Fundamental understanding on the relation between turbulence and wind turbines is key to improve reliability, predictability, and integration of wind farms into electrical grids. Particularly, turbulence plays a dominant role in the structure of a single turbine or a wind farm's power output. For a single wind turbine, field and laboratory experiments were performed to unravel the structure of the power output fluctuations of horizontal-axis wind turbines based on incoming flow turbulence. A physical basis for the behavior of temporal power fluctuations and their spectral structure was established based on the incoming flow turbulence and structural properties of the turbines. For a wind farm, the performances of turbines downstream are significantly influenced by their upstream counterparts. The turbulence intensity and integral time scale plays the dominant role influencing the downstream turbines. Due to the advection and turbulent diffusion of large-scale structures, a spectral oscillation exists with the product of a sinusoidal behavior and an exponential decay in the frequency domain

Some Distinctive Research Fields in Additive Manufacturing with Metal Powder by Dr. Wei Li

Laser assisted additive manufacturing with blown powder, which is also called Directed Energy Deposition (DED), is a nontraditional but very popular advanced manufacturing process. Now more and more industries, research institutes, and high-educational universities are joining in these field. With highly concentrated energy from laser beam, a spatially and temporally mobile melted pool is generated on the substrate, which moves following numerical-controlled (NC) toolpaths. The supplied metal powder is blown into the melted pool by argon gas, melted rapidly, and then solidifies with high cooling rate. A three-dimensional part is fabricated successfully from bottom to top with layer-by-layer style. This presentation will introduce author's distinctive current/future research fields in utilizing laser assisted additive manufacturing. These research fields include fabricating multi-functional materials with customized compositions, repairing metallic part, improving part's strength and manufacturing productivity through high laser transverse speed. Additive manufacturing's advantages (flexibility, high-efficiency, rapid solidification, etc) are embodied through these research fields. This presentation will also introduce author's research achievements and plans in modeling AM process, including thermal history simulation, phase change, powder flow, microstructure morphology, and thermodynamics analysis in multi-material system.

Modeling and Control of Complex Fluid Flows Using Systems Theory and Optimization by Dr. Armin Zare

Turbulence is often the fundamental mechanism that causes energy losses in engineering applications involving wall-bounded fluid flows, such as flows over aircraft wings and turbine blades. The success of control design for mediating a complicated phenomenon, such as turbulence, relies on the accuracy of models that are used to describe it. Current practice is largely empirical, and relies on sophisticated numerical simulations and experiments, which are costly, time-consuming, and not suitable for facilitating controller design. On the other hand, advanced measurement techniques and high performance computing have made large data sets available for a wide range complex fluid flows. Drawing on this abundance of data, dynamical models can be constructed to reproduce structural and statistical features of turbulent flows, opening the way to the design of effective model-based flow control strategies. On par with the dramatic upswing from the fields of machine learning and optimization in leveraging big-data for modeling, we propose methods that utilize data to refine the predictive capability of dynamical models that arise from first principles and thereby offer a new perspective on tackling issues of robustness and generalizability. In parallel and from a complementing viewpoint, we take a model-based approach in devising active/passive flow control strategies.