Date: April 7th

Time: 11:00 AM

Location: Maryland Hall 110

Speaker: Dr. Suresh Menon
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Title: "A Multi-Scale Simulation Methodology for Multi-Phase Turbulent Combustion near Limiting Conditions"

Abstract

Currently, an area of serious focus of gas turbine engine design manufacturers is achieving stable lean combustion since pollutant emission (e.g., CO, NO, UHC, and soot) is minimized and fuel efficiency is increased. However, lean combustion systems are particularly sensitive to small perturbation in heat release that can result in flame extinction. Experiments also show that as the fuel-air mixture is made lean, CO emission first decreases and then suddenly increases rapidly as the lean flammability limit is reached. This rapid increase in CO (and in some cases, UHC) is observed in all gas turbine engines (i.e., both premixed and spray systems), and is related to the onset of Lean Blowout (LBO) when the flame undergoes rapid instability, undergoes local quenching, and then globally extinguishes. In some engines, large-pressure oscillations are associated with LBO whereas in some systems LBO occurs without any appreciable acoustic signature. LBO and/or flame oscillations are also observed in afterburners and in high pressure military combustor under certain conditions. Prediction of LBO and near-LBO physics requires not only resolution of the time-dependent flow-chemistry interactions but also inclusion of proper chemical kinetics. Furthermore, flame characteristics can change from flamelet-type to distributed reaction zone combustion as conditions close to LBO is reached. As a result, there is a need for a simulation strategy than can simulate a wide range of operational conditions with making any model adjustments. A multi-scale large-eddy simulation (LES) approach has been developed over the last few years that can be used for a wide range of operating conditions without any tunable parameters. A localized dynamic LES model for the subgrid kinetic energy is combined with a subgrid simulation of the scalar reaction-diffusion processes. Soot physics is also included in this formulation and relatively detailed kinetics is included using in-situ adaptive tabulation (ISAT) and/or artificial neural networks (ANN). Although computational cost is significant, efficient parallel implement allows application of this tool to full-scale premixed and liquid-fueled gas turbines. Progress in application to various laboratory and operational devices will be discussed. Extension of this approach to simulate supersonic combustion and detonation in two-phase reactive mixtures has also been accomplished, and will be briefly addressed as well.