MECHANICAL ENGINEERING COLLOQUIUM

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DYNAMIC MIXING TIME-SCALE MODEL FOR MULTIPLE MAPPING CONDITIONING APPROACH APPLIED TO LES OF REACTIVE FLOWS

ABSTRACT

Accurate prediction of turbulent reactive flows — central to the design of gas turbines, IC engines, and rocket combustors — requires closure of the highly non-linear chemical source term arising from turbulence-chemistry interaction (TCI). This talk introduces the sparse-Lagrangian Multiple Mapping Conditioning (MMC) approach coupled with Large Eddy Simulation (LES), a transported probability density function (PDF)/filtered density function (FDF) method that combines the merits of the PDF and Conditional Moment Closure frameworks. By localising molecular mixing in an independent reference space — typically mixture fraction — MMC intrinsically closes the reaction source term while permitting a sparse resolution of stochastic particles relative to the LES grid, making it computationally attractive for complex flames. The talk outlines the governing MMC-LES equations for gas-phase and two-phase (spray) combustion, the role of the mixing time-scale in controlling molecular mixing, and the evolution of mixing models from isotropic and anisotropic formulations to a fully dynamic model that evaluates its coefficients locally, removing the need for tuned constants. Representative applications to lifted spray flames and piloted flames with strong local extinction and re-ignition illustrate the capabilities and current limitations of the approach.

ABOUT THE SPEAKER

Dr. Santanu De is a Professor in the Department of Mechanical Engineering at the Indian Institute of Technology Kanpur. He earned his M.Tech. from IIT Kanpur and his Ph.D. from the Indian Institute of Science, Bangalore. By integrating high-fidelity computational modeling of turbulence-chemistry interactions—utilizing PDF and MMC approaches—with state-of-the-art optical diagnostics, his group bridges fundamental combustion science with practical energy applications.