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Radiative Heat Transfer in Turbulent Methane/Hydrogen Flames

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Abstract
Hydrogen has become a major focus of industrial heat decarbonisation strategies, and is a leading candidate for reducing carbon dioxide emissions from high-temperature process heat. However, replacing natural gas or methane with hydrogen does more than eliminating carbon from the fuel. It changes the combustion process, temperature field, and radiative heat transfer that delivers a substantial fraction of the energy to the load in fuel-fired furnaces. Understanding and controlling these changes is therefore essential to maintain thermal performance, heat fluxes, and product quality during the transition to hydrogen. This lecture examines, through detailed numerical simulations, how thermal radiation evolves as the H_2 content of a confined turbulent CH_4/H_2 jet diffusion flame is varied from pure methane to pure hydrogen. Accurate models are used to simulate radiative transfer, accounting for the non-grey nature of thermal radiation emitted and absorbed by the combustion products and for the interaction between turbulence and radiation. The influence of the hydrogen content in the fuel blend on the temperature field, radiative heat source, net radiative heat fluxes, and fraction of radiative heat loss are examined under different operating conditions. These include constant thermal power, mass flow rate, volumetric flow rate, and Reynolds number. The results reveal how changes in fuel composition and operating conditions modify the balance between convection and radiation and, consequently, the transfer of energy from the flame to the surrounding walls. The lecture will highlight the implications of these changes for the design and operation of industrial furnaces undergoing the transition from natural gas to hydrogen.