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CFD Analysis of Ammonia/Hydrogen Combustion Performance under Partially Premixed and Non-premixed Modes with Varying Inlet Characteristics

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Abstract : Ammonia (NH_3) is the alternative carbon-free fuel of the future for its promising applications. Investigations on NH_3-fuel blends recommend using hydrogen (H_2) to increase the heating value of NH3, promote combustion performance, and improve NOx efflux mitigation. To further examine the effects of this concept, the study analyzed the combustion performance, in terms of turbulence, combustion efficiency (CE), and NOx emissions, of NH3/fuel with variations of combustor diameter ratio, H2 fuel mole fraction, and fuel mass flow rate ($\dot{m}$). The simulations were performed using Computational Fluid Dynamics (CFD) modeling to represent a non-premixed (NP) and partially premixed (PP) combustion under a two-dimensional ultra-low NOx Rich-Burn, Quick-Quench, Lean-Burn (RQL) combustor. Governed by the Detached Eddy Simulation model, it was found that the diameter ratio greatly affects the turbulence in PP and NP mode, whereas $\dot{m}$ in PP should be prioritized when increasing CE. The NOx emission is minimal during PP combustion, but NP combustion suggested modifying $\dot{m}$ to achieve higher CE and Reynolds number without sacrificing the NO generation from the reaction.

Keywords : combustion efficiency, turbulence, dual-stage combustor, NOx emission
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