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Invited Talk Abstract

Printing the Path to Fuel Flexibility: Sequential Combustion Enabled by Additive Manufacturing for Hydrogen-Based Fuels

The transition toward low-carbon energy systems is driving growing interest in hydrogen and hydrogen-derived fuels, but their use in combustion systems presents fundamental challenges. High flame temperatures, increased propensity for flashback and autoignition, and significant variations in fuel properties require combustion technologies that are both robust and adaptable to changing fuels and operating conditions.

This keynote explores sequential combustion as a pathway toward fuel-flexible, hydrogen-capable combustion systems, with a particular focus on the opportunities offered by additive manufacturing. Sequential combustion distributes heat release across multiple stages, providing additional degrees of freedom to manage temperature, emissions, combustion stability, and fuel–air mixing. This architecture offers opportunities to accommodate a wider range of fuels while maintaining high efficiency and low emissions.

Additive manufacturing complements this approach by overcoming many of the geometric constraints of conventional manufacturing. It enables complex internal flow paths, integrated fuel injection and cooling features, tailored mixing structures, and rapid iteration of combustion hardware. Together, sequential combustion and additive manufacturing offer an opportunity to rethink combustor architectures around the properties and requirements of future fuels. The talk examines how this combination can support the development of efficient, stable, and low-emission combustion systems for hydrogen, ammonia, and other hydrogen-derived fuels, with fuel flexibility as a central design objective.