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Exploring Ultra-Lean Combustion Potential in Micro Thermophotovoltaic Applications through Trapped Vortex Concept at Microscale

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Abstract

The present investigation introduces a novel micro-combustor for micro-thermophotovoltaic application. The micro-combustor is a modified version of the conventional Micro Backward Step Combustor (MBSC) and features an additional aft-body to create a trapped vortex. The novel micro combustor is called a Micro Trapped Vortex Combustor (MTVC). This design is inspired from the propulsion and power combustion systems and its suitability for micro-scale application will be assessed using computational fluid dynamics. The investigations are carried out under laminar flow regime, conjugated heat transfer, premixed hydrogen-air, lean combustion and various inflow velocities. The results indicate that the trapped vortex design is very suitable for micro-combustor application since it enhances the flame stability compared to the conventional design. The twin vortices formed in the cavity and downstream the aft-body are responsible of increasing the combustion intensity as the inflow speed increases. Consequently, both the conductive and radiative heat transfers are intensified through the bottom wall, which is very beneficial to micro-thermophotovoltaic systems. Moreover, it was found that the novel MTVC is capable of maintaining combustion at an ultra-lean regime up to $\Phi = 0.5$. More importantly, comparison between both configurations at $\Phi = 0.8$ revealed that the MTVC produces 47% less NOx compared with the MBSC.

Keywords: CFD, Hydrogen, Micro-combustion, NOx emission, Trapped vortex,