Title

Performance of low emissions swirling flames. Influence of diffusers.

Abstract

The major aim of the research is to improve the stabilization of flames of poor stoichiometries by means of a swirling flow. This provides saving of fuel as well as a reduction of contaminant emissions. Swirling burners have some advantages when compared with bluff bodies and cross flows. These are lower head losses and soot, less maintenance tasks. Despite the simple geometrical set-up of the benchmark, the flow pattern shows complex aerodynamic behavior. The simple burner considers the use of two coaxial nozzles: one axial with fuel and another annular with heated air. The expansion of the flow, when entering the chamber will produce the Outer Recirculation Zone. If swirl number is large enough to let the flow turn back into the center, the vortex breakdown phenomenon appears to form an Inner Recirculation Zone limited by two stagnation points located in the axis of the chamber. The region between both recirculation zones with high shear is where mixture of fuel-air occurs. In addition, combustion is a demanding task that has strongly benefited from HPC facilities. This work is devoted to gain an insight of flow pattern associated to different swirl numbers and diffusers as well as mixtures ranging from rich to lean flames. Axial swirl injector is composed by a certain number of fixed vanes in the annular nozzle. The Swirl number is associated to the angle of the trailing edge of the vanes. Besides, the influence of conical diffusers in the flame performance is analyzed. To sum up, the strong swirl number had the lead stagnation point near the discharge of the nozzles and provided a reaction length lower than half diameter of the chamber. Intermediate swirl numbers have bigger Outer Recirculation Zones and the reaction length is more than one diameter. Finally the low swirl number does not have any vortex breakdown and the reaction length has several diameters. Bearing in mind the influence of conical diffusers, it is more important in the case of intermediate swirl numbers since the diffuser reduces the reaction length. These models were tested a temporal resolution is 10E-6 s/timestep with spatial resolution 5 times larger than Kolmogorov scale. It was found that for mesh of 10 million cells without multigrid, the optimum is 360 processors.

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