Investigation of injector geometry effects on flow dynamics in hydrogen double-swirl burners

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Abstract
In present days, hydrogen represents a possible substitute in combustion applications, since it burns with no CO2 release in the ambient. Due to its high reactivity and high temperatures with respect to traditional fuels, hydrogen increases the flashback propensity and enhances NOx emissions. The aim of this study is to design an atmospheric double-swirl burner fed by hydrogen characterized by low NOx emissions and study the influence of the injector geometry on the flow field structure in isothermal conditions.

The burner consists of a central premixed swirled injector, placed inside an annular co-rotating swirled air flow. These streams are injected into an octagonal combustion chamber. The chamber is equipped with quartz windows to facilitate camera access for performing isothermal Stereo-PIV measurements. Due to this requirement, an equivalent airflow rate is used instead of hydrogen. The tests are conducted considering an equivalent thermal power of 12 kW, a secondary air split ratio of 0.6 and a global equivalence ratio of 0.45. The average flow field is analysed for various injector geometries, investigating the impact of axial holes presence and injector diameter on the flow characteristics.

From Stereo-PIV measurements emerges that the geometry has a limited impact on the swirl number. The presence of corner recirculation vortex CRV and central reverse flow zone CRFZ emerges in all the examined geometries, nevertheless it is reduced by a decrease of the injector diameter.

The current findings represent an initial phase preceding the evaluation of the burner in reactive scenarios. Furthermore, these results will be useful for validating and enhancing a numerical simulation, thereby enabling a more profound comprehension of how injector geometry and operating parameters impact the flow dynamics.