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Assessment of thermochemical field reconstruction based on Sparse Sensing methodology applied to a MILD cyclone burner

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The development of reduced order models (ROM) for a reference cyclone flow combustor, characterized by a strong recirculation of combustion products and consequently able to reach MILD combustion conditions, was studied. The QR column pivoted QR algorithm (QRCP) with Householder transformations and the data-driven Sparse Sensing (SpS) methodology [1,2] were applied to achieve an optimized temperature and species sensor placement configuration capable of correctly predicting the thermochemical state of the system. MILD process of pure methane (CH_4)/Air mixtures of reactants at atmospheric pressure was considered as a function of the global input equivalence ratio ($0.6 < \phi < 1.1$) and the nominal thermal power ($6 < P < 8$ kW). In particular, a numerical data set was built by performing RANS simulations where the k-ϵ Re-Normalization Group (RNG) was used as turbulence model assuming incompressible and ideal gas conditions and the turbulence-chemical interaction (TCI) was handled by the Flamelet Generated Manifold (FGM) [3], coherently with the experimental campaigns performed and the numerical evidence of the system [4]. The methodology was applied to create a framework with multiple constraints in order to establish different sensor configurations. Results showed an effective predictive performance of the developed models, with relative reconstruction errors (RRE) of around 10% for almost all thermochemical species. In addition, the effect of applying other constraints, such as distance between sensors or restricted regions, was analyzed. Slight improvements in performance are observed with respect to the unconstrained scenarios, providing valuable information on key locations and features, which can be exploited in the design of experiments and monitoring and control strategies.

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