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CH4/air mesocombustor at 3 atm: Numerical simulation and experiments

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In Improvements in understanding how to design future mesocombustors, currently under rapid development in particular for propulsion, e.g., for UAVs, and as meso-electrical power generators, are mandatory. In view of this scenario and, to advances previous analysis carried out at ambient pressure by the authors, the numerical and experimental investigation of a 254 mm3 swirling cylindrical mesocombustor, fed by methane/air at an equivalence ratio Φ=0.7 and at 3 bar, has been performed. The combustion pressure has been chosen based on the values quoted in literature for centimetre sized gas turbine. Exhaust gas temperature and composition have been measured for several mass flow rates. A reduction in chemical efficiency is observed by increasing the input thermal power (i.e. the total mass flow rate) at fixed equivalence ratio due to the shorter gas residence time. The operative condition corresponding to high efficiency and smaller mass flow rate has been numerically investigated adopting the RANS k-epsilon approach, with finite rate chemistry kinetic mechanism (GRIMech 1.2, 32 species and 177 reactions) and the EDC turbulence-combustion coupling model. Gas temperature at the exhaust section and chemical efficiency are predicted and compared with the corresponding experiment. Numerical and experimental results show to be in fair agreement, and the predicted chemical efficiency differs from the measured value of about 1 %.Despite the small size of the meso-combustor, it is possible to achieve a relatively high combustion efficiency, making it suitable for miniaturized power generation devices. The relatively high chemical efficiency is due to the relatively long average gas residence time and to a wide recirculation zone that provide heat and radicals to the flame, coupled with the fairly good mixing due to swirl motion and the impinging air/fuel jets.

Biography

A. Minotti has completed his Ph.D. in Theoretical and Applied Mechanics in 2008 at the Sapienza University of Rome and his postdoctoral studies in Aerospace Propulsion in 2010, delving into mesocombustion, real gas phenomena and radiative heat transfer. He has been Assistant Professor in Aerospace Propulsion since 2012 at the Department of Mechanics and Aerospace Engineering of the Sapienza University of Rome. He has authored and co-authored several papers in reputed journals and has been working on several international research projects since 2003.

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