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Coupling high-speed imaging diagnostics to study a LOX/GH2 flame in a high-pressure rocket combustor.

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A new high pressure rocket engine-like combustor, was designed and tested on Onera's Mascotte test bench. A modular design was chosen to face several objectives, all ambitious, but quite distinct. Unlike the previous combustors that were used on Mascotte over the years, this one is water-cooled to sustain higher mixture ratios and long duration tests, and it is fed with five injectors instead of a single one.

The first version, dedicated to heat flux measurements at the walls, was tested in 2010. These tests were presented in the previous edition of the EUCASS [1]. The present paper deals with a second version, in which the first ferrule is replaced by a visualization module fitted with four portholes for optical diagnostics. Two test series were run in 2012 with the collaboration and the financial support of the French space agency CNES: the first one in gas/gas operation (both propellants injected in gaseous phase at room temperature), and the second one in liquid/gas conditions (liquid oxygen atomized by gaseous hydrogen).

During the liquid/gas tests, two high speed digital cameras were synchronized, the first one recording the chemiluminescence of the OH* radical and the second one recording the liquid oxygen (LOX) jet in a backlighting optical configuration. By means of a threshold selection method [2], this set-up permits to distinguish both phases and to measure the LOX jet penetration length. Six operating points were tested, at sub- and supercritical chamber pressures (P = 35 bar and P = 65 bar) and J ranging from 4 to 16, where J stands for the momentum flux ratio at the injection ($J = (\rho V^2)_{H2}/(\rho V^2)_{O2}$). A typical value of J in an actual rocket engine would be around 10. It was observed that the LOX jet penetration length decreases with both P and J.

Combustion stability was studied through Fourier analysis of the different signals acquired at a sufficiently high data rate. The pressure fluctuations (measured with Kistler transducers) were compared to the fluctuations detected on the instantaneous images of both high speed cameras, i.e. fluctuations of the OH* emission and fluctuations of the liquid jet surface.

References

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