Paper ID: 4795
student

SPACE PROPULSION SYMPOSIUM (C4)
Propulsion Systems I (1)

Author: Mr. Yoann MERY
France

Dr. Sébastien Ducruix
CNRS, France
Prof. Sébastien Candel
CNRS, France

CRYOGENIC FLAMES SUBMITTED TO HIGH FREQUENCY ACOUSTIC WAVES

Abstract

High frequency combustion instabilities have technical importance in the design and development of liquid rocket engines. These phenomena usually involve a strong coupling between transverse acoustic modes and combustion. In this article, this problem is investigated with model scale experiments. The system, operated on the experimental bench Mascotte of Onera, features a multiple injector combustor (MIC) comprising five coaxial elements fed with liquid oxygen and gaseous methane. It is equipped with a novel actuator based on a modulation wheel blocking the exhaust system in a peridodic fashion. This device was designed to obtain the highest possible levels of transverse oscillation in the MIC. The system was operated for different set of injection parameters. Mean chamber pressures vary from 1 MPa to 5.5 MPa, hence reaching transcritical injection conditions. Different operating flow parameters and in particular the momentum flux ratio J is changed to examine their effects on the coupling between transverse acoustic modes and cryogenic flames. The level of oscillation observed in these experiments reaches the expected value of 20 % of the mean pressure in the chamber under resonant conditions. This value is of the order of magnitude of oscillations observed in real scale unstable rocket engines. It corresponds to pressure oscillations of several bars, and acoustic levels close to 200 dB in the chamber. Five pressure transducers, located on the lateral walls of the chamber, provide the spatial structure of the pressure field and help identify the eigenmode being excited. Two quartz windows allow optical visualization of the flame dynamics under these externally imposed acoustic levels. The jet motion and the CH* emission of the flames are imaged using synchronized high speed CMOS cameras operated at 24 kHz. Images indicate that each flame has an important periodic motion at the modulation frequency. At the same time, the mean shape of the flames is observed with an intensified camera equipped with an OH* filter. Flames structures are modified in different ways depending on the mode excited and on the chosen set of injection parameters. One observes that the expansion angle can be augmented or that some of the flames can be made shorter and more compact, and that the set of flames can become assymmetric. These experiments and the data gathered with the various diagnostics give strong evidences that the coupling between transverse acoustic modes and combustion is highly influenced by the liquid core break-up and atomization processes and that the coupling may influence the modal distribution in the chamber.