

RESEARCH FACILITIES FOR STORABLE PROPULSION AT PPRIME INSTITUTE

Bastien BOUST,¹ Marc BELLENOUE,¹
Miguel MARTIN-BENITO,² Stéphane ORIOL,² and Lilian PREVOST,²

¹PPRIME Institute, CNRS – ISAE-ENSMA – Poitiers University, Poitiers, France

²Launchers Directorate, CNES, Paris, France

bastien.boust@ensma.fr, <https://pprime.fr/>

Abstract: PPRIME institute is associated with CNES to investigate the physical phenomena involved in chemical propulsion systems using green storable propellants. Unlike hydrazine-based propellants, these reactants deserve interest for their low toxicity and ease-of-use. To begin with, the propellants of interest include hydrogen peroxide as oxidizer, and fuels such as kerosene or alcohol. Experimental studies focus on the key processes encountered in chemical propulsion, namely atomization, ignition, and combustion.

For this, several facilities have been developed and tailored to investigate these processes at increasing scale. Their complementary features address the very physics of storable propellants thrusters, from the atomization of injectors using inert fluids (AILEFS, see Fig. 1), to the combustion of relevant propellants at laboratory scale (ACSEL: 20 g/s, 5 bar, see Fig. 2), and their propulsive performance at an upper scale (PERGOLA: 400 g/s, 50 bar, 1 kN, see Fig. 3).

Within this project, ignition systems are investigated to initiate the combustion of these green, liquid, low-volatility propellants. A hydrogen-air torch is used as a reference, but catalytic ignition or hypergolic combinations are also being developed. Spray characterization also deserves deep investigations to reach stable, throttleable operation. Experimental measurement include optical diagnostics (chemiluminescence, spray sizing and velocity using Phase-Doppler Interferometry or High-Magnification Shadowgraphy) and time-resolved measurements (pressure, thrust, heat flux). These measurements provide crucial operational parameters such as injector spray properties (Sauter diameter SMD , velocity distribution, spray angles), combustor performance (characteristic velocity c^*), and propulsive performance (thrust coefficient C_F , specific impulse I_{sp}).

The resulting set of facilities offers a wide range of operating conditions (pressure, flowrate, water or real propellants), with a high modularity (injectors, chambers, nozzles, ignition systems...) that makes it ready for advanced studies on storable propellants thrusters.

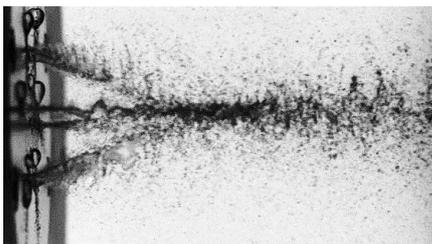


Fig. 1: Spray imaging on AILEFS facility

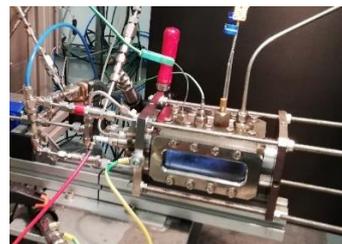


Fig. 2: ACSEL facility



Fig. 3: PERGOLA facility



Exhaust plume during a firing test on PERGOLA