TEST FACILITY FOR HIGH SPEED MIXING EXPERIMENTS

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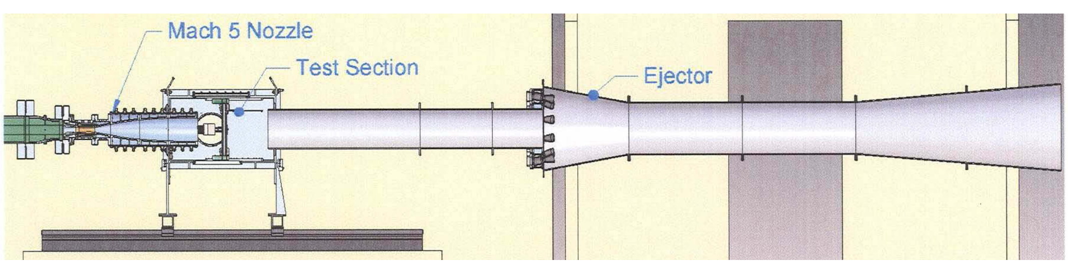
The performance of high speed airbreathing propulsion systems depends on how well the air and the fuel are mixed. For shock-induced combustion ramjets or "shcramjets", where fuel is injected near the nose of the vehicle well ahead of the combustion region, and for scramjets, where the fuel is injected directly into the combustor, this mixing takes place at supersonic or even hypersonic speeds. Due to the extreme operational environments, experimental data are difficult to obtain, so Computational Fluid Dynamics modelling can be a valuable tool to better understand the fundamental fluid dynamic processes taking place. However, to validate the modelling of these very complex multiphysical phenomena, a test facility has now been built at DRDC Valcartier with the goal of providing essential benchmark experimental data.

For close to 50 years, propulsion research at DRDC Valcartier focused exclusively on solid propellant rockets. Beginning in 1994, in close collaboration with TNO Defence, Security and Safety in the Netherlands, airbreathing propulsion research began on ducted rockets, including experiments with their direct-connect vitiated air test facility capable of supplying hot, high-pressure air to simulate supersonic flight conditions. Also in response to the need of a test capability at DRDC Valcartier, construction began soon after on the Airbreathing Propulsion Test Facility. The key component is a pebble bed storage heater consisting of a 6 m high steel tank which houses a 4 m high, 0.5 m diameter column of 19 mm diameter aluminum oxide pebbles (spheres), approximately 1600 kg total mass, and surrounded by a castable refractory concrete of 92% aluminum oxide that is 20 cm thick, and a layer of insulating firebrick 10 cm thick. Exhaust from a natural gas burner flows through the bed and heats the pebbles to a design temperature around 1700 K. Heating of the bed is done gradually to prevent thermal shock of the pebbles which may result in dust. While not critical for air/fuel mixing experiments, the cleanliness of the air will be an advantage for any future combustion experiments that could be influenced by the presence of pollutants, such as water vapour and combustion radicals, from a vitiated-air facility. The test facility also includes a 7 m^3 tank for air storage, a computer controlled pneumatically operated control valve, a hot valve with a zirconia piston and seat, and a vacuum ejector.

Some preliminary tests have taken place with a wedge placed near the exit of a Mach 2.6 nozzle. Future mixing experiments, with a simulated fuel injected from the wedge, would be representative of what could be expected in the combustor of a scramjet flying at hypersonic speed. However, data measured at higher supersonic or even hypersonic speeds are more representative of the situation for the shcramjet. To carry out these experiments, a Mach 5 freejet nozzle with a 140 mm diameter exit has been fabricated, and will be connected to an enclosed test section with optical access. The nozzle exit conditions are nominally 10 kPa static pressure and 200 K static temperature at a mass flow rate of 3 kg/s.



The authors would like to thank the Propulsion Group and Prototype Service at DRDC Valcartier, M. Noël and D. Couture of Numérica, R. Vaivads and M. LaViolette of the Royal Military College of Canada, D. Gauthier of Carleton University, J. Verreault of McGill University, and TNO.