Small-Scale Rotating Detonation Engine Development and Testing

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Rotating detonation engines (RDE), initially devised in the 60s and 70s [1], have seen a resurgence in research in the last 10 years as a possible means of obtaining more efficient propulsive devices. This includes experimental, e.g. [2–3] and numerical, e.g. [4–5] work.

This project aims at developing a small scale RDE compatible with requirements from competitions such as the Intercollegiate Rocket Engineering Competition, up to 10 cm in diameter, less than 160 Ns of impulse, operating on H_2-O_2 and testable in an available, roughly 6 m^3 blast chamber. These constraints have led to designing an engine operating on the smallest possible mass flow rate. The problem of a minimum mass flow rate, identified in [6–7] was encountered and is discussed further in these same proceedings by the authors. We report on the development and testing of a minimum scale RDE.

The current engine design consists of a 2.5-mm-thick annular combustion chamber preceded by a mixing chamber. The two are separated by a replaceable choking plate outfitted with 200–300 holes of less than 0.031” diameter. The side of the combustion chamber is outfitted with a small pre-detonator tube of 3.2 mm diameter with a low-power, automotive-type spark plug. Initial tests have been performed by feeding a $2H_2+O_2$ mixture with an upstream stagnation pressure between 20 and 150 psi. Mixture ignition, although not detonative, was achieved at all pressures, and most tests show signs of flashback into the mixing chamber, probably due to the choking plate flow not being choked. Up to 50 psi stagnation pressure, the flow in the combustion chamber was ignited by the predetonator. Between 75 and 150 psi, the predetonator failed and was replaced by a thin-explosive-layer transfer tube (Exel™ shock tube, Orica) initiator. At 150 psi, the mass flow rate is roughly 1.6 lbs/min, 1/10th the calculated minimum for operation.

The gas feeding system is being upgraded to make use of 2 accumulators to achieve short duration, high stagnation pressure flows, allowing testing up to the calculated operational mass flow rate.

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