INVESTIGATION OF LASER IGNITION IN HYBRID ROCKET MOTORS

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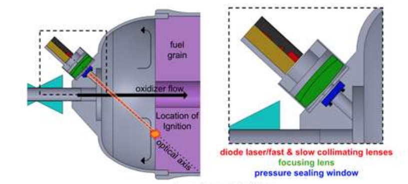
Program: SURP

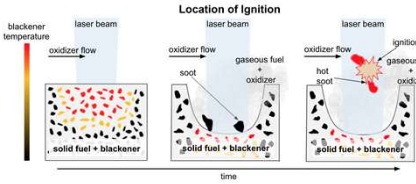
Project Objective:

Lightweight, restart-capable ignition systems are a key goal of current hybrid motor technology development. This research investigates the performance of a diode laser system that leverages a "heated soot" ignition mechanism unique to motors with mixed-phase propellants (SURP 2017/18 Program Result).

- Igniter mounting scheme:



- Ignition mechanism:



Primary **project objectives**:

1) Characterize igniter performance (ignition delay)
2) Demonstrate reliable operation across numerous motor restarts
3) Demonstrate ignition in vacuum

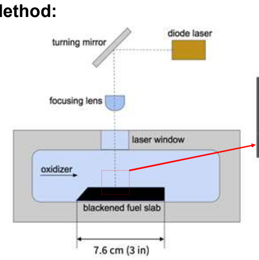
Benefits to NASA and JPL:

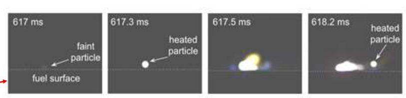
Hybrid motor development at JPL, led by Dr. Ashley Karp and Dr. Elizabeth Jens, focuses on the development of a small-scale motor for interplanetary CubeSats, targeting a reference mission involving orbit insertion at Mars and subsequent flybys of Phobos and Deimos. The goal is to reduce the entry cost to orbiting science missions around a variety of celestial bodies. The laser igniter is intended as a key piece of technology needed to implement this small-scale propulsion device.

Objective 1

Method:

- Ignition delay performance was studied in a slab-burning visualization chamber
- High speed imaging data collection
- Results shown for ABS plastic fuel, gaseous oxygen oxidizer

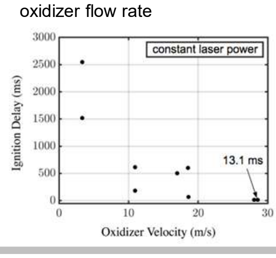




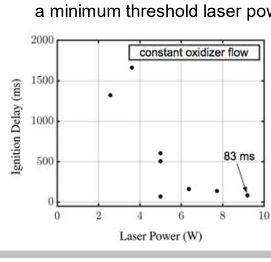
ignition event | flame holding

Results:

- Ignition delay is a strong function of oxidizer flow rate



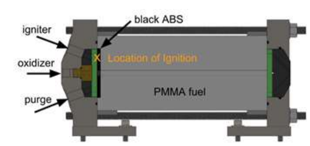
- Consistent ignition delay requires a minimum threshold laser power



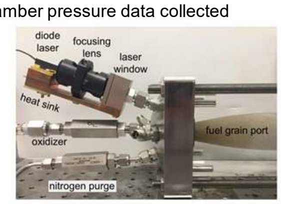
Objective 2

Method:

- Laser system and ignition target fuel added to experimental motor
- Multiple burns conducted per fuel grain (gaseous oxygen oxidizer)
- High speed imaging and chamber pressure data collected

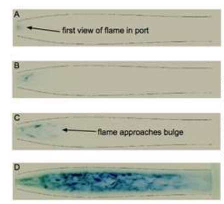


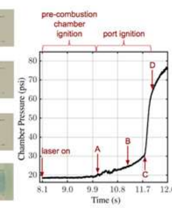
Stanford Motor

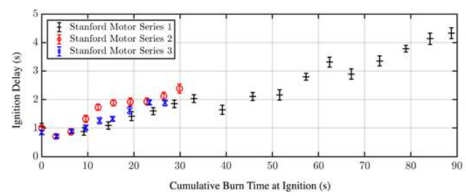


Results:

- 36 successful motor restarts
- Ignition transient broadens with each successive ignition





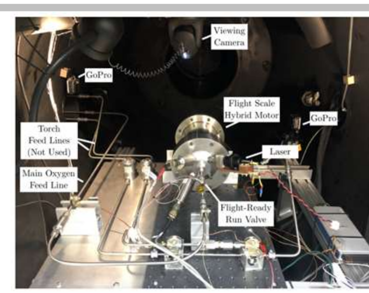


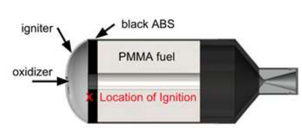
- Ignition delay increases as fuel grain regresses
- Ignition delay trends consistent across multiple test series

Objective 3

Method:

- Laser igniter installed on JPL's hybrid motor
- 29 ignition tests in a vacuum chamber at JPL

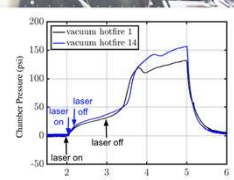


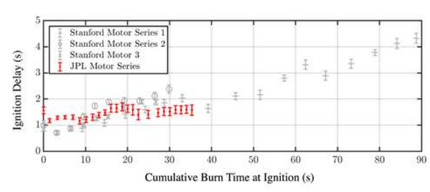


JPL Motor

Results:

- Ignition demonstrated for a sequence in which the laser is turned on before oxygen flow is initiated
- Ignition transient independent of laser pulse length





- 24 successful ignitions
- Less variation in ignition delay across ignitions as compared to Stanford tests (further testing needed to determine why)

Publications:

Dyrda, D., Korneyeva, V., and Cantwell B., "Diode Laser Ignition Mechanism for Hybrid Propulsion Systems," AIAA Joint Propulsion Conference, August 2019.

Dyrda, D., et al., "Diode Laser Ignition Testing for PMMA/GOX Hybrid Motors," AIAA Joint Propulsion Conference, August 2019.

Jens, E., et al., "Low Pressure Ignition Testing of a Hybrid SmallSat Motor," AIAA Joint Propulsion Conference, August 2019.

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