100-lbf LO_2/CH_4 RCS Thruster Testing & Validation

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Motivating Undergraduates in Science and Technology Project

Meet The Engine

- 100 pound thrust liquid Oxygen-Methane thruster sized for RCS (Reaction Control System) applications

Innovative Design Characteristics

- Simple compact design with minimal part count
- Gaseous or Liquid propellant operation
- Affordable and Reusable
- Greater flexibility than existing systems
- Part of NASA'S study of "Green Propellants"

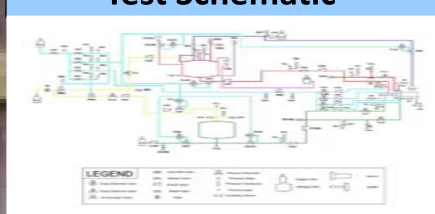
Test Stand/Thruster Preparation

- Installed new main propellant valves (Valvetech)
- Calibrated and installed new pressure transducers (Statham)
- Leak checked Actuation/Purge Systems with GN_2
- Installed stand at test site with camera coverage
- Leak checked Fuel/Oxidizer Systems with LN_2

DAQ/Instrumentation Verification

- Checked DAQ System for proper/consistent excitation and actuation
- Wiring checked for continuity and proper operation with valves, transducers, and thermocouples
- Calibrated pressure transducers both out of system and installed in system
- Thermocouple inputs checked with Thermocouple Calibrator
- Tested valves for proper actuation

Test Schematic



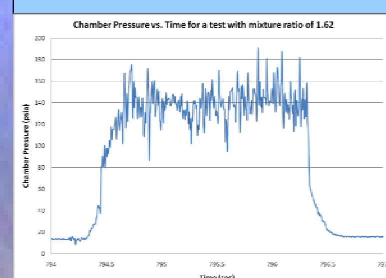
Procedural Flow Chart

SBIR Phase II Hot-Fire Test

Future Applications & Benefits

- Spacecraft/Launch Vehicle Attitude Control Systems (ACS)
- In-Situ Utilization of CH_4 on Mars for potential propellant usage
- Environmentally-Friendly exhaust products

Test Results



Cold-Flow Test/Hot-Fire Simulation

- Dry run walkthrough of procedures and documentation
- Hot-fire test simulation conducted with LN_2 as replacement for LO_2 and LCH_4
- Full test simulation included:
  - Step-by-step operations according to procedures
  - Design and verification of test/safe sequences
  - Control of test stand through Labview GUI
  - Tracking of test operations and conditions
  - Interaction with test technician for safe operation of test stand

Hot-Fire Testing/Data Analysis

- Hot-fire testing validated performance and functionality of thruster
- Thruster's dependence on mixture ratio has been evaluated
- Data has been used to calculate performance parameters such as thrust and Isp
- Data has been compared with previous test results to verify reliability and repeatability
- Thruster was found to have an Isp of 131 s and 82 lb_f thrust at a mixture ratio of 1.62

Test #	Description	Duration (s)	Environment	Injector Propellant Supply	Igniter Propellant Supply	Avg. Pc (psia)	Ox Tank Press. (psia)	Fuel Tank Press. (psia)	Ox Mdot (lbm/s)	Fuel Mdot (lbm/s)	O/F	Test Goal	Result
	Sparker	0.1	Atmospheric	-	-	-	-	-	-	-	-	Ensure sparker has an even spark	
20090724_5028_001	Igniter Cold Flow	10	Atmospheric	-	Liquid	-	325	325	0.01000	0.00667	1.50	Cold Flow Igniter Test	
20090724_5028_002	Igniter Cold Flow	10	Atmospheric	-	Liquid	-	325	361	0.01000	0.00588	1.70	Cold Flow Igniter Test	
20090724_5028_003	Igniter Cold Flow	10	Atmospheric	-	Liquid	-	325	405	0.01000	0.00526	1.90	Cold Flow Igniter Test	
20090724_5028_004	Thruster Cold Flow	10	Atmospheric	Liquid	Liquid	-	325	325	0.20000	0.13333	1.50	Cold Flow Injector Test	
20090724_5028_005	Thruster Cold Flow	10	Atmospheric	Liquid	Liquid	-	325	361	0.16600	0.09790	1.70	Cold Flow Injector Test	
20090724_5028_006	Thruster Cold Flow	10	Atmospheric	Liquid	Liquid	-	325	361	0.20000	0.10526	1.70	Cold Flow Injector Test	
20090727_5028_001	Igniter	0.5	Atmospheric	-	Liquid	101.05	319.94	317.03	0.01015	0.00732	1.39	Cryo Propellant Supply	fail
20090727_5028_002	Igniter	0.5	Atmospheric	-	Liquid	111.43	323.275	319	0.01000	0.00588	1.70	Cryo Propellant Supply	partial success
20090727_5028_003	Igniter	0.5	Atmospheric	-	Liquid	114.44	378.1845	330.2745	0.01000	0.00526	1.90	Cryo Propellant Supply	partial success
20090727_5028_004	Igniter	0.5	Atmospheric	-	Liquid	123.52	381.97	343.85	0.01000	0.00588	1.70	Cryo Propellant Supply	success
20090727_5028_005	Igniter	0.5	Atmospheric	-	Liquid	138.89	407.37	350.91	0.01000	0.00526	1.90	Pulsed Cryo Propellant Supply	success
20090727_5028_006	Thruster	2	Atmospheric	Liquid	Liquid	N/A	382.695	355.726	0.20000	0.13333	1.50	Cryo Propellant Ignition Test	fail
20090727_5028_007	Thruster	2	Atmospheric	Liquid	Liquid	139.69	384.336	366.823	0.01200	0.00742	1.62	Cryo Propellant Ignition Test	success
20090727_5028_008	Thruster	2	Atmospheric	Liquid	Liquid	145.45	433.2325	343.0651	0.01281	0.00747	1.71	Cryo Propellant Ignition Test	success
20090727_5028_009	Thruster	2	Atmospheric	Liquid	Liquid	142.84	385.3766	396.0307	0.01111	0.00773	1.44	Cryo Propellant Ignition Test	success

Test Matrix

Acknowledgements:

1. Orion Propulsion Inc. "SBIR Final Report", December 2008.
2. Alex Conley (Orion Propulsion Inc.)
3. Chase Renegar (Orion Propulsion Inc.)
4. Brent Sandlin (Orion Propulsion Inc.)
5. Jesse Hillig (Orion Propulsion Inc.)
6. Brown, Charles D. *Spacecraft Propulsion,* 1996.
7. Hill, Philip and Carl Peterson. *Mechanics and Thermodynamics of Propulsion*. Ed. 2, 1992.
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