Conceptual Design Review

AA284 Team A - January 27, 2020

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Goal

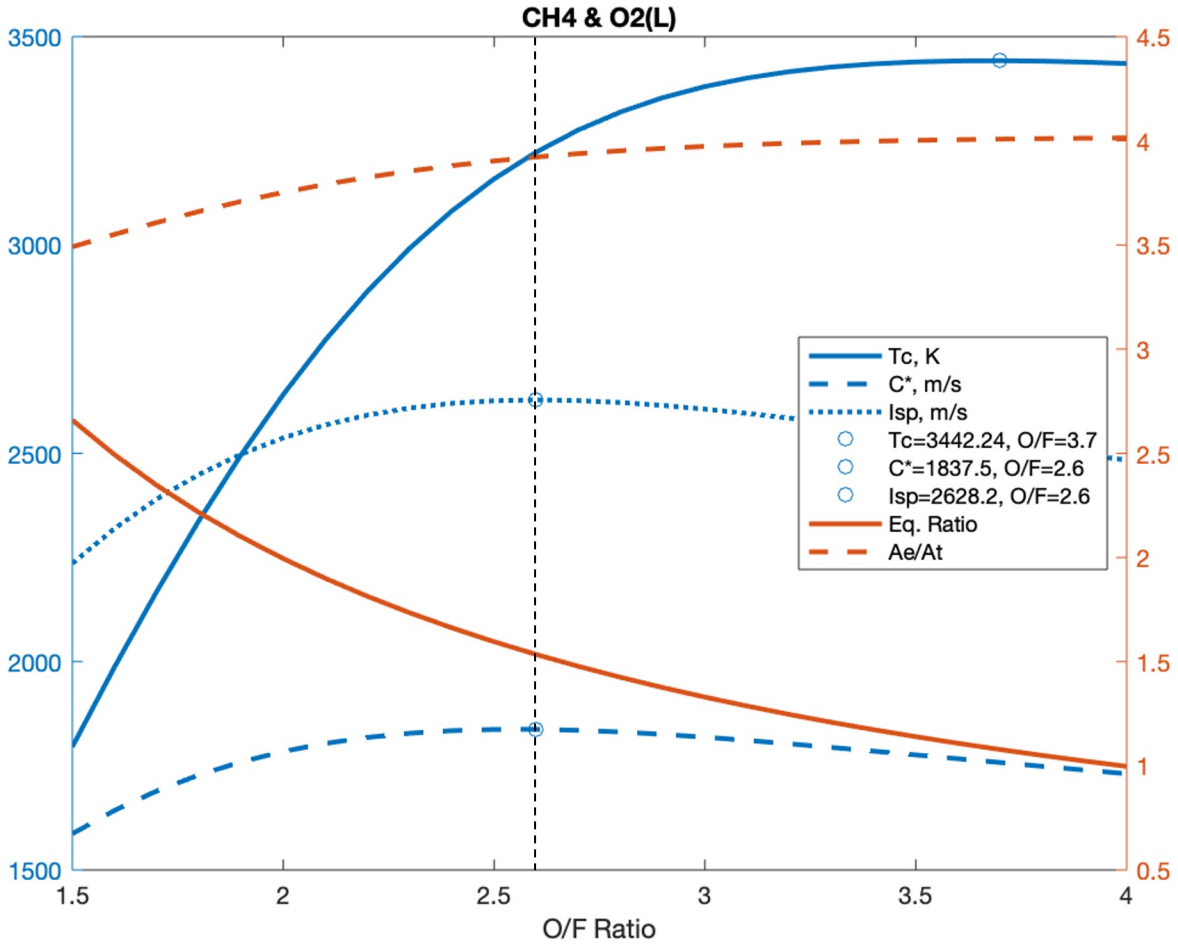
Startup, shutdown, and restart of LOx-GCH_4 engine

Stretch Goals:

- Stable combustion (Pc oscillation <5% mean)
- Measure C* efficiency
- Image engine startup and reignition

Top Level Design Parameters

Oxidizer	Liquid Oxygen
Fuel	Gaseous Methane
Chamber Pressure	24 bar (~350 psia)
Thrust	2.37 kN (~530 lbf)
Throat Diameter	29.6 mm (1.17 in)
O/F ratio	2.6
Ox Mass Flow Rate	0.650 kg/s
Pressurization System Type	Helium
Nozzle Expansion Ratio	3.92 (Sea Level Optimal) or up to 6.37 (Pe = 0.5 Pa, Isp = 285 s)
Gas phase burn?	Yes
Burn Time	5s (each reignition)
Isp	260 sec



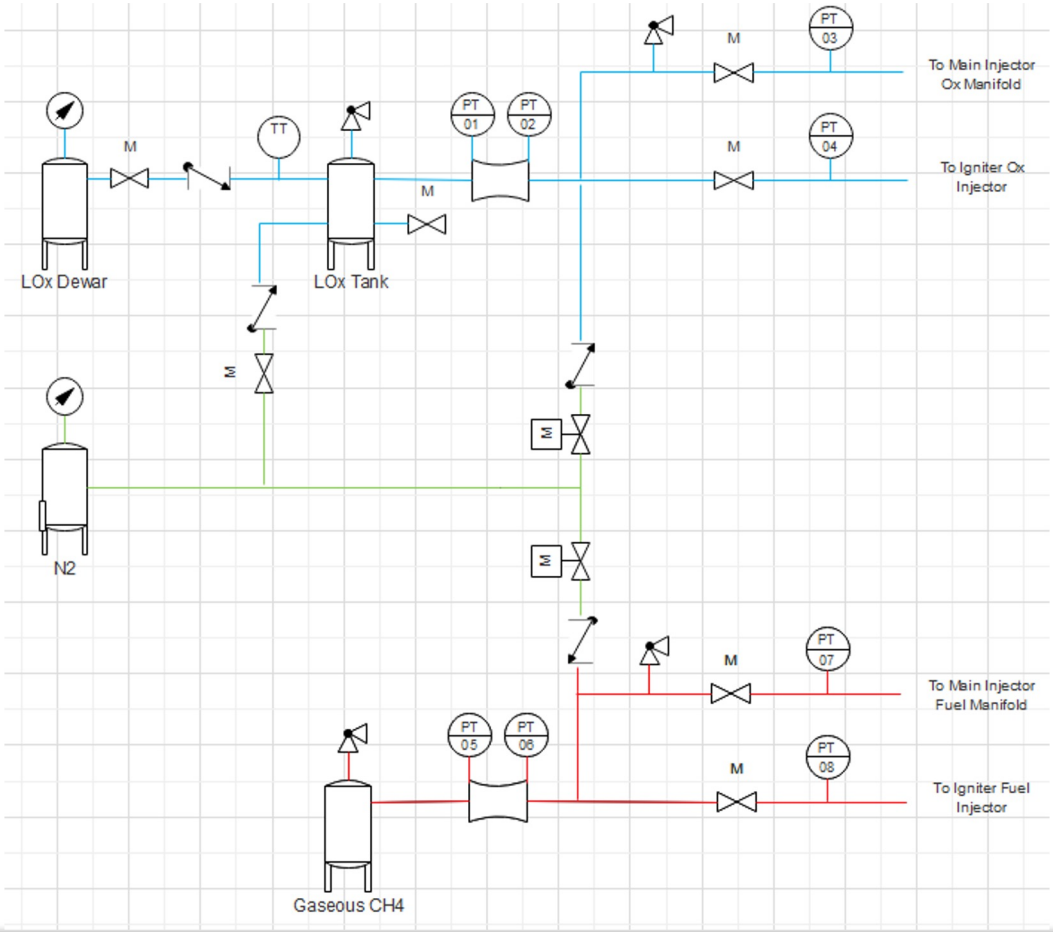
CEA Inputs:

- CH4, 293.00 K
- O2(L), 90.17 K
- Pc = 24 bar
- Pc/Pe = 23.7 (Pe = 1 atm)
- Frozen Flow

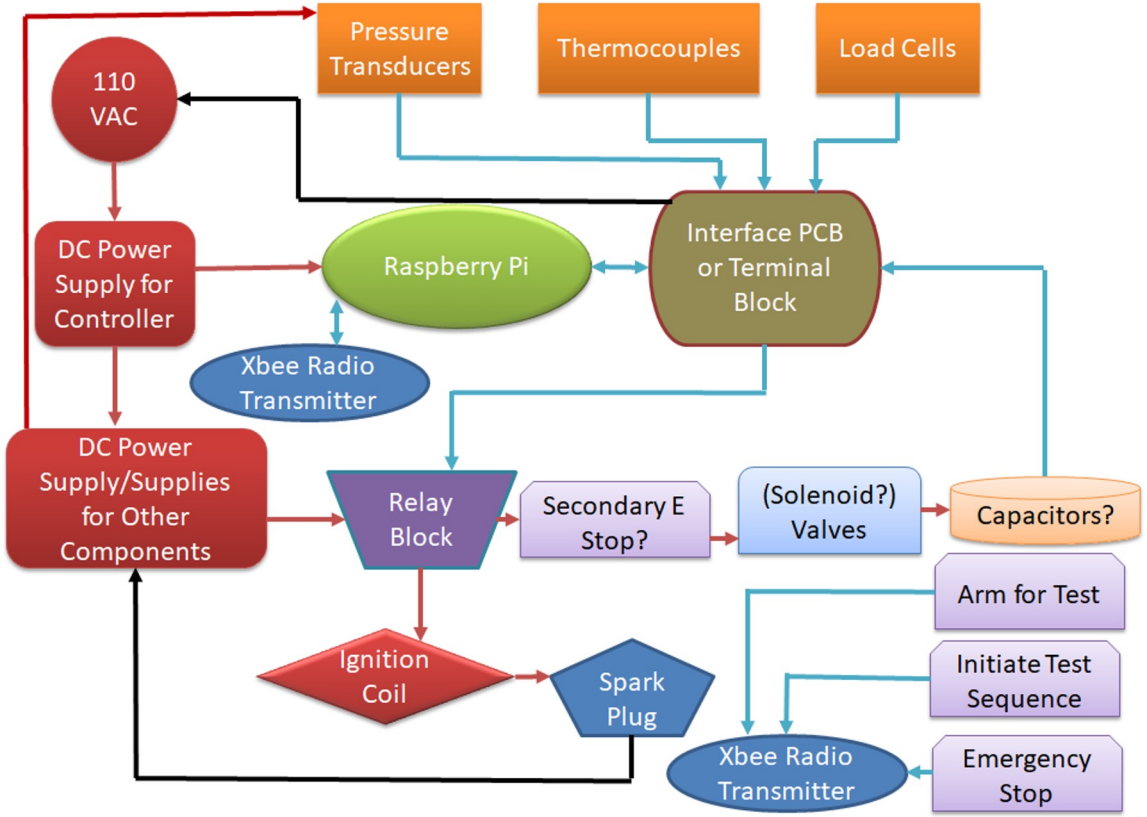
At O/F = 2.6

- T = 3222 K
- C* = 1837.5 m/s
- Isp = 2628.2 m/s (268 s)

P&ID


LOx Dewar
M
TT
LOx Tank
PT 01
PT 02
M
PT 03
M
To Main Injector Ox Manifold
PT 04
M
To Igniter Ox Injector
M
N2
M
M
Gaseous CH4
PT 05
PT 06
PT 07
M
To Main Injector Fuel Manifold
PT 08
M
To Igniter Fuel Injector

Avionics


Pressure Transducers
Thermocouples
Load Cells
110 VAC
DC Power Supply for Controller
Raspberry Pi
Interface PCB or Terminal Block
Xbee Radio Transmitter
DC Power Supply/Supplies for Other Components
Relay Block
Secondary E Stop?
(Solenoid?) Valves
Capacitors?
Arm for Test
Initiate Test Sequence
Emergency Stop
Ignition Coil
Spark Plug
Xbee Radio Transmitter

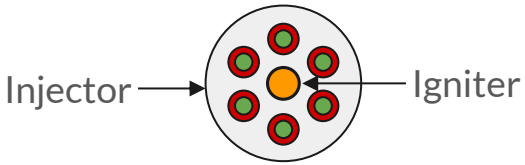
Injector & Igniter

Injector

- Coaxial Elements
- Ox center, CH4 annular
  - Swirl Ox stream?
- Additively Manufactured?

Igniter

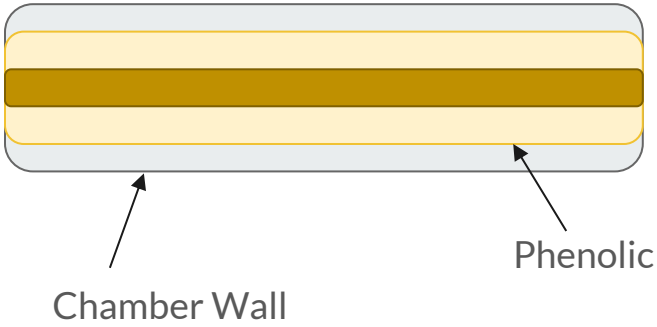
- Liquid Ox/ Methane, Stoichiometric mix
- Swirl injection of Oxygen
- Combustion chamber with a throat
- External cooling jacket
- Automotive spark plug (>10W)
- Centered in main injector face



Combustion Chamber

Chamber Wall

- Thick-Wall Al6061 Tube Stock
  - ¼” Wall
  - 4.5” OD
  - FS ~11
- Ablator: Canvas phenolic resin laminate tube
  - ¼” Wall
  - 4” OD (3.5” ID)



Chamber connects to injector plate & nozzle with flanged bolted joints

- Bolts sized to ensure joint at nozzle is weak link in event of chamber overpressure (FS ~1.5)

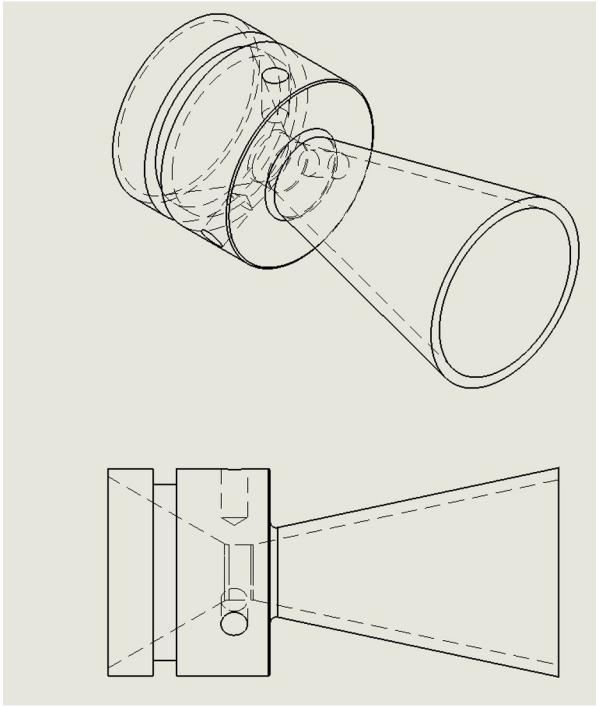
Chamber max flow velocity ~85 m/s (from CEA chamber fluid density & chamber cross section area)

Nozzle

High-Density Graphite

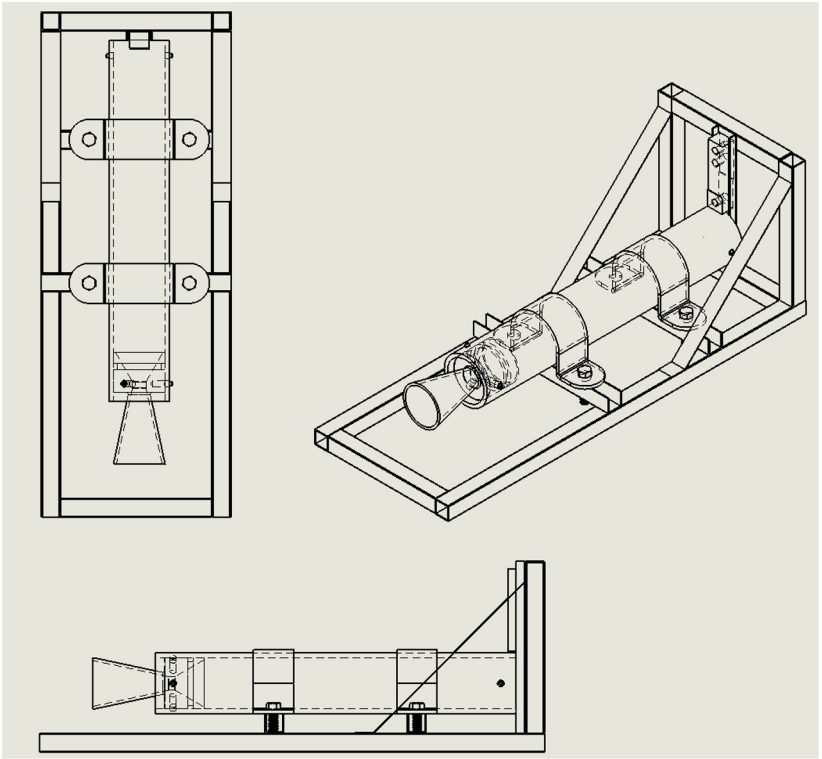
Throat ID: 29.6 mm (1.166”, Chamber AR 9)

Exit ID: 58.7 mm (2.31” Ae/At 3.92 - or 74.8 mm/2.94” Ae/At 6.37)



Test Stand

- Design for 10 kN
- Rosette on horizontal to measure bending stress
- Easily accessible for tubing
- Budget: 500 dollars
- Used for cold flow and full engine test
- Blast shielding for prop tanks
- Valve mounting



Test Plan

Subsystem tests

- Injector cold flow
- Igniter reliability (multiple ignition attempts, do we get 100% success?)
- Prop feed system pressurization & purge/safing
- Avionics startup, data acquisition, shutdown

Full system test

- Single (5 second) burn
- 2 burns back-to-back
- Three burns back-to-back

Preliminary Budget

Item Group	Cost ($)
Plumbing System	4000
Chamber & Nozzle	1500
Propellants	250
Injector & Igniter	3500
Pneumatics & Electrical	500
Test Stand	250