Study and Development of a H_2O_2 based Liquid Rocket Engine

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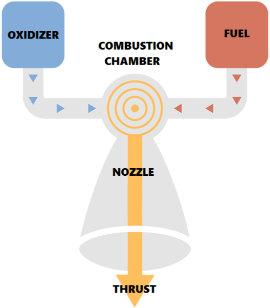
Introduction to Liquid Rocket Motors



Main characteristics

- Oxidizer and fuel stored in tanks
- Two controllable feeding lines
- Different cooling system solutions

Advantages

- High specific impulse
- Operation flexibility
  - Multiple shut down and re-ignition
  - Mass flow throttling
  - Mixture ratio control
- Long burning times

Disadvantages

- High manufacturing costs
- Technological complexity

Cooling systems

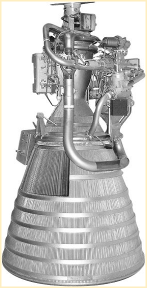
Passive methods

- Very expensive materials
- Small scale thruster

200N Bipropellant Thruster,Orbital Propulsion Centre, Lampoldshausen, Germany

Active methods

- Regenerative cycle
- Technological complexity
- Larger scale engine



RL10, Aerojet Rocketdyne

Why Hydrogen Peroxide?

$$H_2O_2 \leftrightarrow H_2O + 1/2O_{2(g)} + 98kJ/mol$$

Main characteristics

- No toxicity
- High volumetric specific impulse
- Easy storable at room temperature

$\Downarrow$

Reduced management,storage and processing costs

HTP (High Test Peroxide)
Concentration $> 80\%$

Versatility:

- Monopropellant
- Bipropellant $\rightarrow$ combustion reaction with fuel

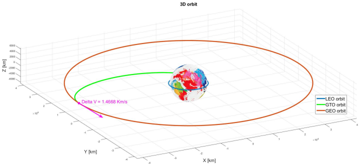
$\Downarrow$

$$Isp_{MMH/N_2O_4} \backsimeq Isp_{HTP/Kerosene}$$

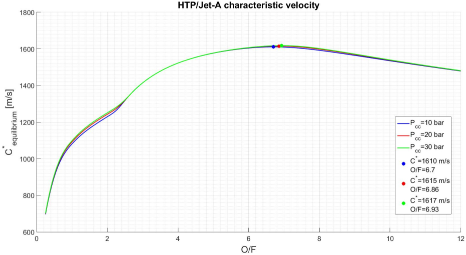
Aim and innovation of this work

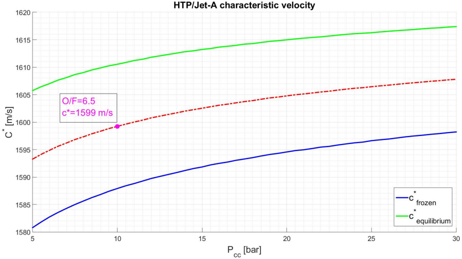
- **Aim**: study and develop a liquid engine based on HTP as a good substitution for the hydrazine based ones
- **Innovation**: study the coupling of HTP propellant and double vortex flow field

Project parameters



$$Isp = \frac{c^* c_f}{g_0} \ , \ T = g_0 \dot{m} Isp$$

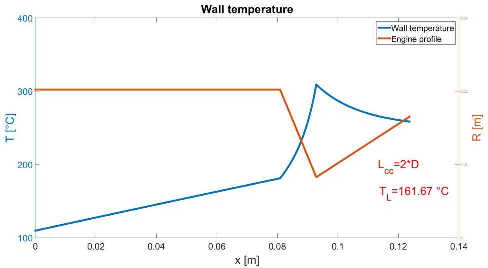


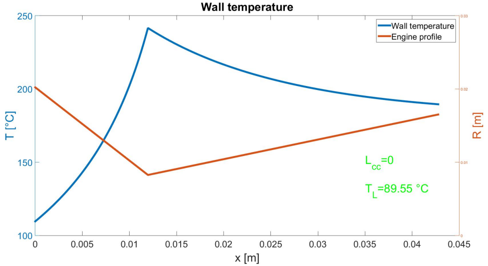


Kick apogee motor

Oxidizer mass flow	120 $[g/s]$
Oxidizer	HTP
Fuel	Kerosene
O/F	6.5
MEOP	10 $[bar]$
Throat diameter	16.8 $[mm]$
c^*	1599 $[m/s]$
ε	220 – 330
Thrust vacuum	420 – 440 $[N]$
Isp	310 – 330 $[s]$
ΔV	1.4688 $[km/s]$
t_b	1.456 $[hours]$

Preliminary design

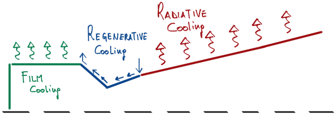


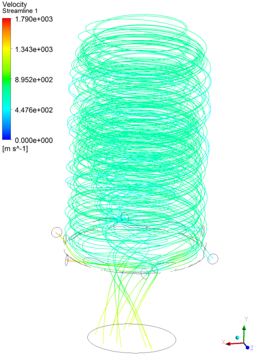


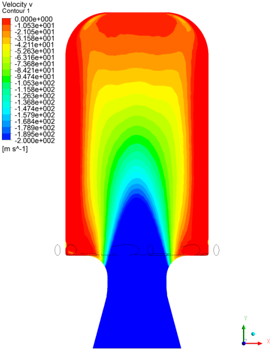
HTP

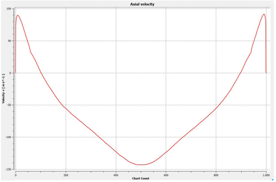
- $T_L max = 120^\circ C$
- $\dot{m}_{cool} = \dot{m}_{ox}$

$\Downarrow$









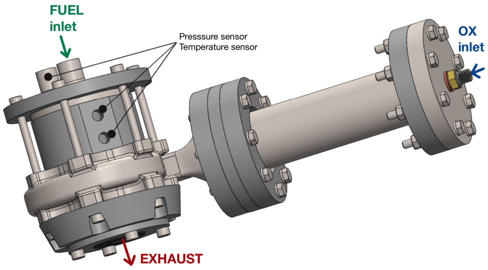
CFD analysis

- CFX/Fluent commercial code
- RANS equations
- $k - \varepsilon$ turbulent model
- HTP Monopropellant
- Double vortex

Note:

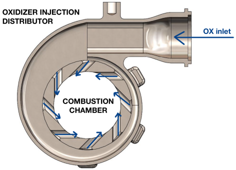
- CR $\geq 30 \Rightarrow$ recirculation on the wall
- Negligible injection angle effect
- No distributor effect

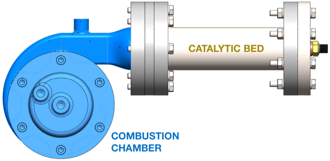
Engine design



Main characteristics

- Battleship design
- Multiple configurations
- High safety factor
- 3D printed components

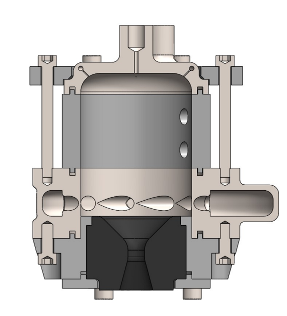




Engine configurations

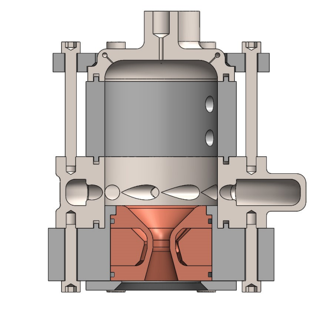
Short burning time

- Uncooled nozzle
- Fuel injection investigation



Long burning times

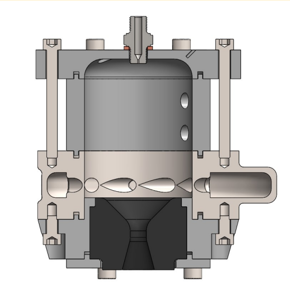
- Nozzle cooling
- H_2O coolant



Fuel injector configurations

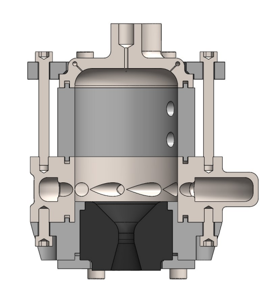
Commercial injector

- Single injector
- Axial injection
- Full cone spray configuration



Custom configuration

- Multiple injection ports
- Radial injection
- 3D printed plate



Work done

- Preliminary design of the engine
- CFD analysis of the flow structure
- Design the engine
- Implementation of the fuel feeding line

Future work

- Conclusion of the test bed implementation
- Engine production
- Numerical investigation
- First fire test campaign

Thank you! Any questions?