Study and Development of Throttleable Hybrid Rocket Motors

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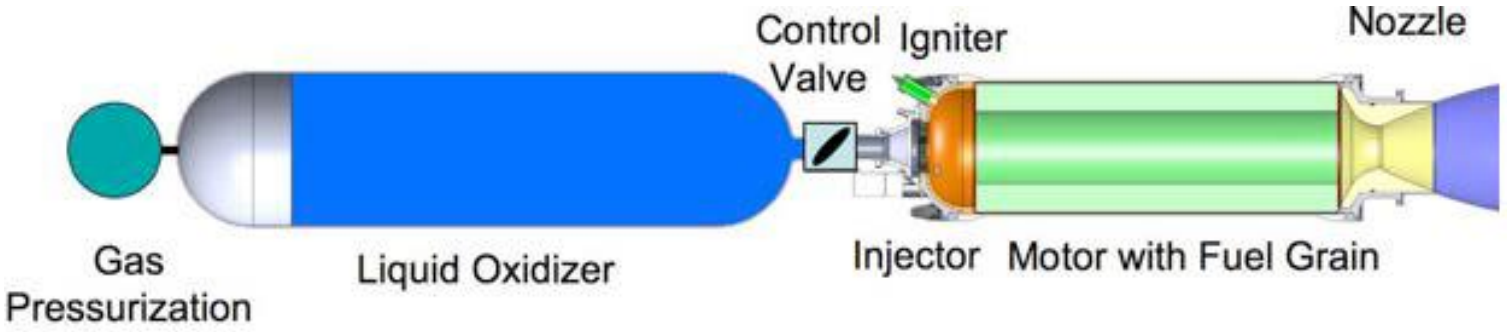
Introduction to Hybrid Rocket Motors



Main characteristics

- Oxidizer in the tank, Fuel in the combustion chamber
- One controllable feeding line
- Different technological solutions and propellant formulations

Advantages of Hybrid Rocket Motors

Reactants Separation

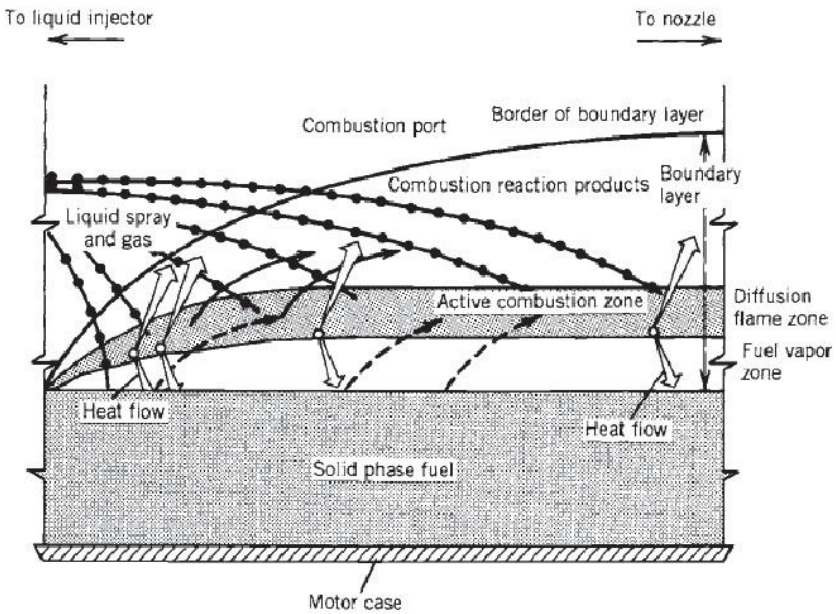
- Safety during the handling and manufacturing
  $\Rightarrow$ Low operative cost
- Oxidizer flow control
  $\Rightarrow$ Mission abort and throttlability
- Simpler than liquid engines
  $\Rightarrow$ Low manufacturing cost

Non-hazardous propellant formulation

- Reduced pollution and toxicity (Green propellants)
- Safety during development
  $\Rightarrow$ Low development cost

Disadvantages of Hybrid Rocket Motors

Reactant separation $\Rightarrow$ Diffusive flame mechanism



Disadvantages

- Low regression rates
  $\Rightarrow$ Volumetric efficiency
- Combustion efficiency
- O/F shift
  $\Rightarrow$ Lower specific impulse
- unburned fuel sliver
  $\Rightarrow$ Inert mass fraction

Applications of Hybrid Rocket Motors

Safety, Low overall cost $\Rightarrow$ Peculiar applications

ADV

Sounding Rockets

Private Spaceflight

Most of them require throttling

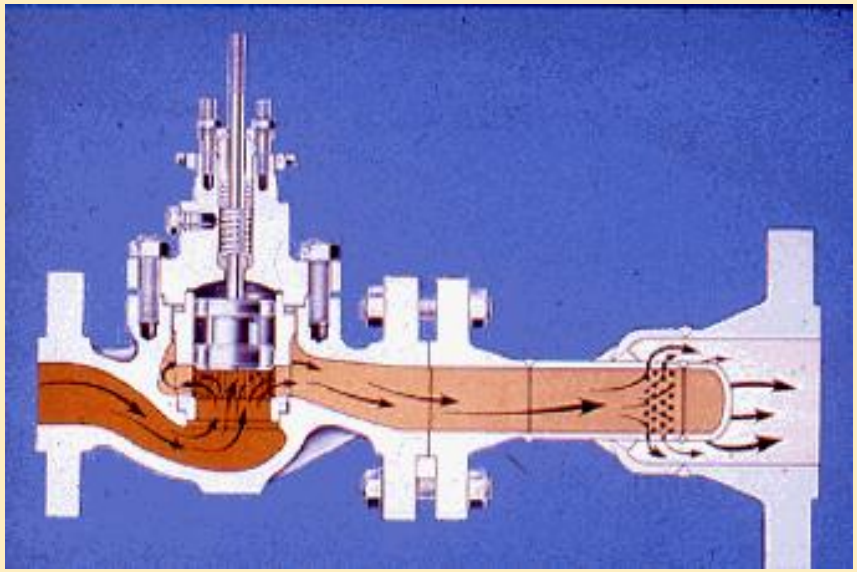
Throttling

Methods derived from the liquid propulsion technology

Variable injection area

- Complex, Expensive: precise relative motion
- Excludes catalytic injection

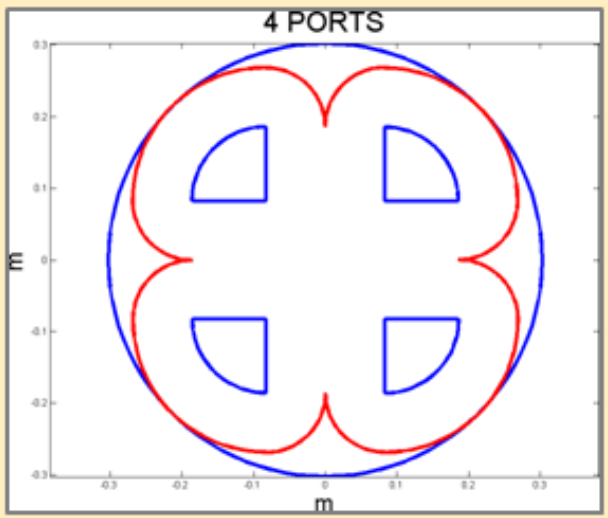
Pressure drop

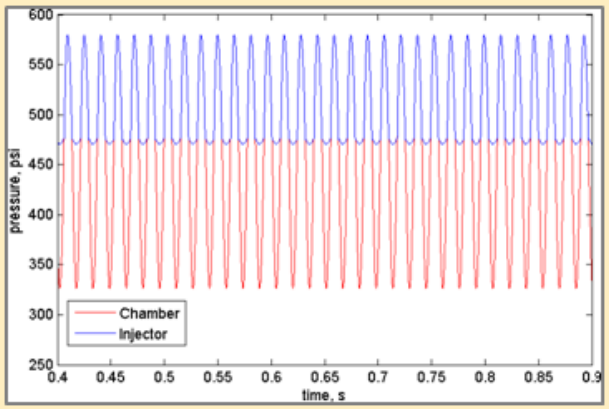


- Pressure drop in the feeding line: additional efficiency loss
- Simple

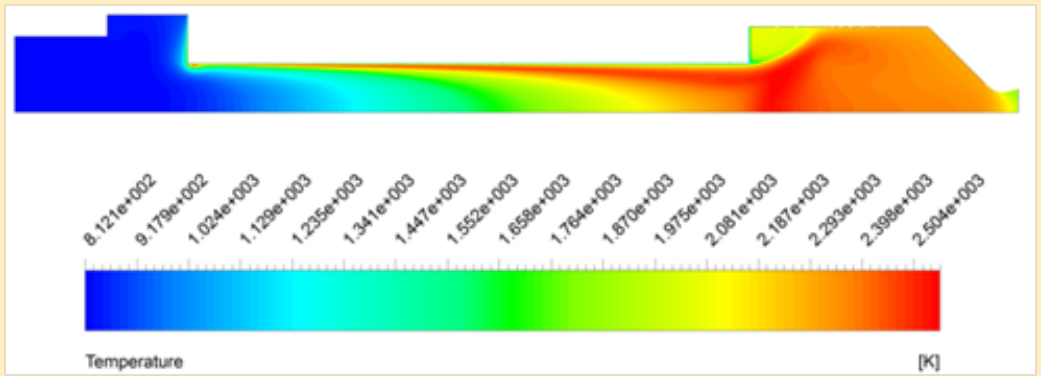
Design heritage

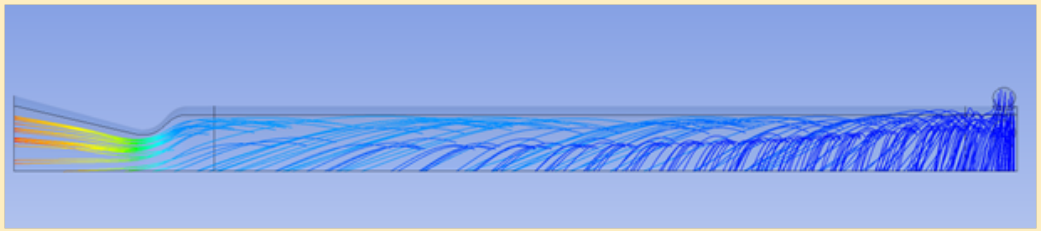
0D /1D Analysis

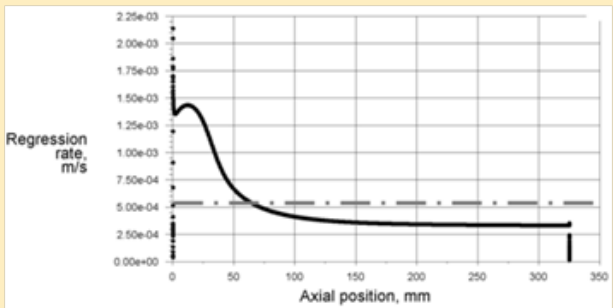


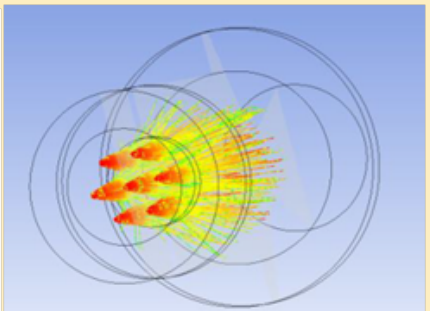


CFD Analysis









Test capabilities

Test facilities

Test bed

- H_2O_2 concentration
- Up to 7kN of Thrust

Activity organization

Level			Activity (Work Package)	hours	year I				year II				year III			
1	**0**	**0**	**State of the art analysis**	**270**	**230**	**40**										
1	1	0	Bibliographical research	70	70											
1	2	0	Numerical methods of design	100	80	20										
1	3	0	Experimental methods of analysis	100	80	20										
2	**0**	**0**	**Numerical Analysis**	**990**	**30**	**220**	**260**	**240**	**170**	**70**						
2	1	0	Definition of the driving parameters	80		80										
2	2	0	Design of the throttling systems	200	20	80	80	20								
2	3	0	Design of the engine	150	10	20	80	40								
2	4	0	Throttling Numerical Analysis	310		40	100	90	80							
2	5	0	Engine Numerical Analysis	250				90	90	70						
3	**0**	**0**	**Experimental Analysis**	**1680**				**20**	**150**	**230**	**290**	**270**	**240**	**240**	**160**	**80**
3	1	0	Experimental set-up arrangement	410				20	130	30	30	140	30	30		
3	2	0	Test campaign (Throttling device)	410					20	180	180	30				
3	3	0	Test campaign (Whole engine)	340								20	130	130	60	
3	4	0	Data analysis and validation	520						20	80	80	80	80	100	80
4	**0**	**0**	**Exploitation**	**120**											**20**	**100**
4	1	0	Cost-effective solutions	60											20	40
4	2	0	Deep-throttling main ascent/descent engines	30												30
4	3	0	Sounding rockets and small boosters	30												30
5	**0**	**0**	**Compilation of Thesis and Reports**	**690**					**20**	**50**	**50**	**70**	**100**	**100**	**150**	**150**

Conclusion

Thank you for your time