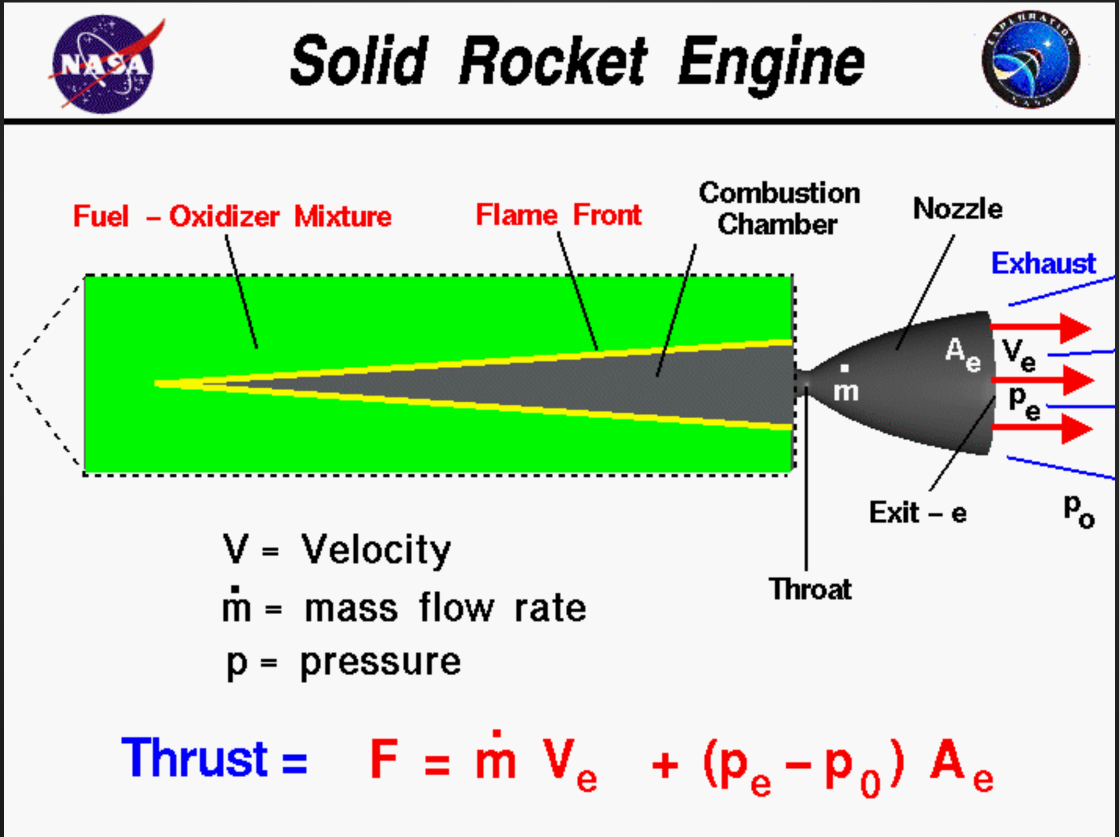
Propulsion

How Does a Rocket Engine Work?



Solid Rocket Engines

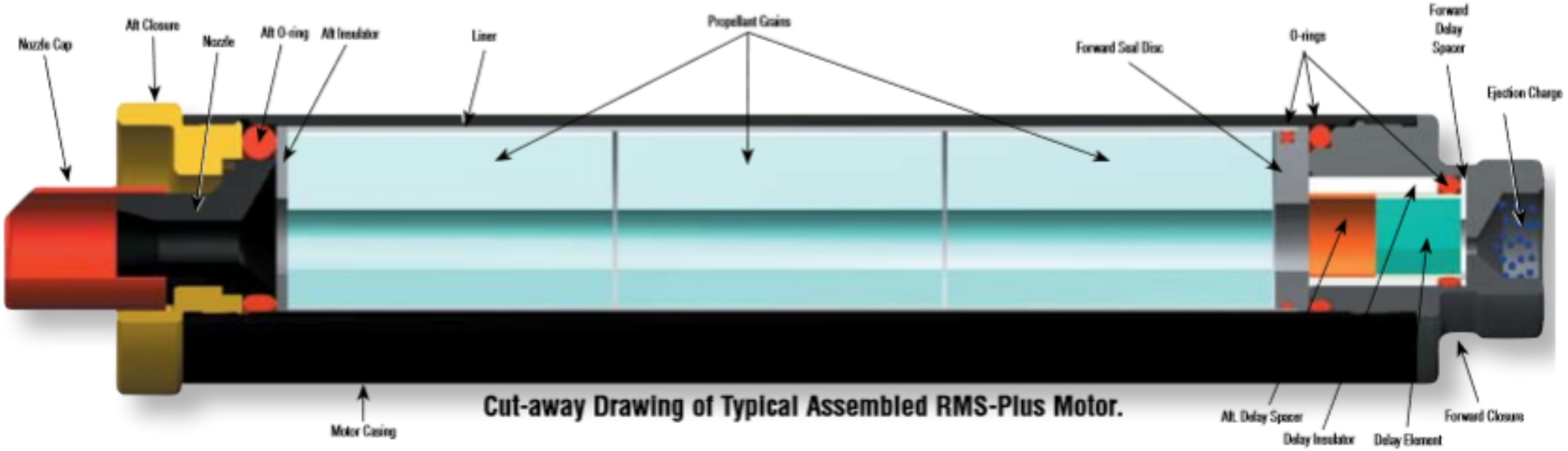
Propellant is a mixture of fuel and oxidizer in a solid grain form.

Pros:

- Stable
- Simple, fewer failure points.
- Reliable output.

Cons:

- Burns until fuel is exhausted
- Typically less efficient than hybrid or liquid motors



Cut-away Drawing of Typical Assembled RMS-Plus Motor.

Contents of a Typical 38mm RMS Reload Kit

Notes:
- Total impulse shown is optimum
- Short–Approx. 6 sec.
- Medium–Approx. 10 sec.
- Long–Approx. 14 sec.
- X-Long–Approx. 18 sec.

Hybrid Rocket Engines

propellent is a mixture of solid+liquid.

-normally liquid oxidizer and solid fuel.

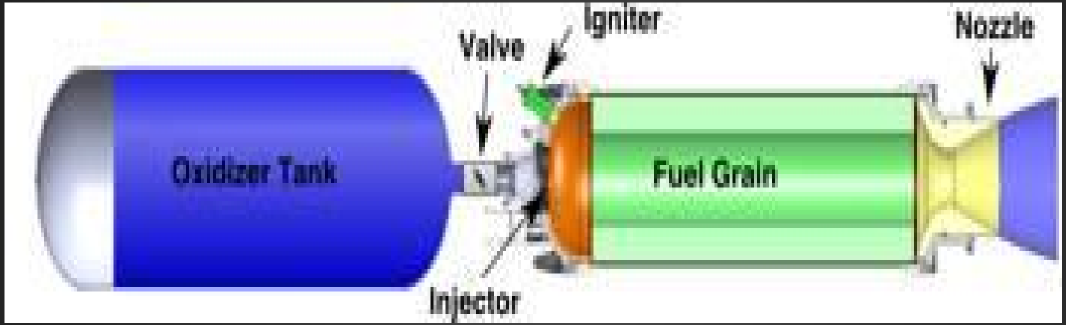
Pros:

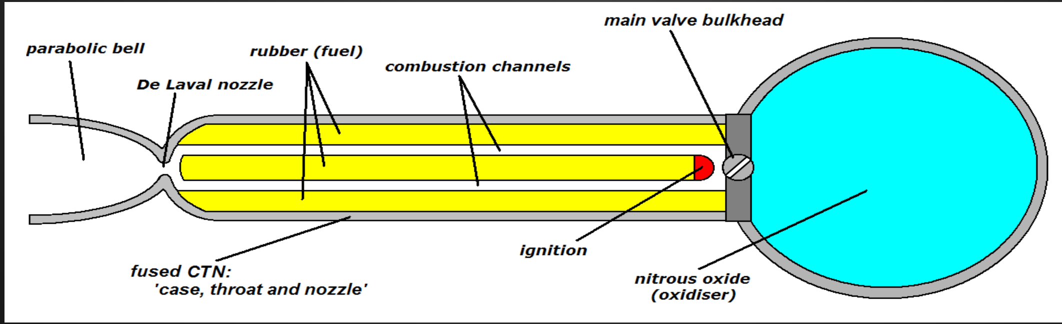
- Simple, moderate cost, relatively safe compared to liquid propellent
- More efficient than solid fuel, equal efficiency as liquid

cons:

- May be an issue with refuelling (solid fuel).
- Ratio of catalyst can alter the efficiency of propulsion.

Hybrid Rocket Examples





Liquid Rocket Engines

Pros

- Most efficient
- High level of control

Cons

- Complex: fuel tanks, pumps, injection nozzles
- Multiple failure points
- Not commercially available.
- Expensive to design, test, and build.

Liquid Rocket Engine

Igniter / Ignition System

- Ignition for a propulsion system is only needed for the initial reaction.
- Igniters can be used later in flight if the fuel’s combustion flame dies.
- Two Types:
  - Propellants that create instantaneous ignition
  - Pyrotech approaches, heating a plate and causing a combustion reaction.
- Issues that arise can be that a failed ignition can fill tanks with fuel and oxidizer, leading to overpressure.

Rules

- Specific rules regarding propulsion are not readily available.
- Commercial cannot use toxic fuel.
- Non-commercial engines must have a firing test (instrumented full duration static firing) completed by March 2015.

Recommendations

- Liquid fuel would be the most complex engine to use for the rocket, but can be throttled, restarted, etc.
- Commercial engines would be cheaper to buy versus creating an engine.
- Solid propellent is the simplest, cheapest engine, but least controllable.
- Hybrid or solid fuel would be cheaper. Hybrid would most likely use nitrous oxide as a catalyst.
- Ignition system would be propellant based rather than pyrotech.

Certification

Level 1:

Type 1 model kit ~ $100/person

Around $30/engine/person

Complete a NAR High Power Certification Application before launch

Level 2:

Written Test - 37 Questions out of 97 Question pool

Must get at least 32 right

Type 2 model kit ~ might be able to use the Level 1 rocket

Around $60/engine/person

Level 2 certification most likely needed (J,K,L Motors)

- A high-power rocket has a total weight of more than 1500 grams and contains a motor or motors containing more than 62.5 grams of propellant or rated at more than 160 Newton-seconds of total impulse. (Class L has 2,560–5,120 N·s)
- Non-commercial motors require full duration static firing with documentation by March 31.
- Required to purchase/launch HPR motors

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What are the three forces acting upon a rocket during the course of its flight?

a. Thrust, rocket diameter and finish.

b. Nose cone shape, thrust and drag.

c. Gravity, thrust and aerodynamic drag.

c. Gravity, thrust and drag are the forces acting on a rocket.

The flight of a high power rocket can be separated into three portions; they are:

a. Ignition, burnout and peak altitude.

b. Powered flight, un-powered ascent and peak altitude.

c. Powered flight, un-powered ascent and descent.

The three phases of flight of a high power rocket are:

(1) Powered flight – the period of time when the rocket motor is producing thrust against gravity and drag.

(2) Un-powered ascent – the period of time after powered flight where the rocket’s momentum allows the rocket to coast to peak altitude and is affected by gravity and drag.

(3) Descent – the return of the rocket to Earth affected by gravity and drag.

For an inherently stable rocket, which statement about the center of gravity (CG) and the center of pressure (CP)
is true?

a. The CG must be behind the CP relative to the desired direction of flight.

b. The CG must be forward of the CP relative to the desired direction of flight.

c. The CG must move forward (in the desired direction of flight) during the motor burn.

For an aerodynamically stable rocket **with the CP behind the center of gravity** (CG), the lift (which is centered aft of the CG) will create a corrective moment to return the rocket to zero degrees angle of attack.

Conversely, if the CP is ahead of the CG the lift will attempt to turn the rocket around so that the CP will again be behind the CG. This resultant “tumbling” is characteristic of an unstable rocket.

Questions?

Helpful Links

- http://www.spacesafetymagazine.com/aerospace-engineering/rocketry/hybrid-rocket-overview-part-2/
- http://www.nar.org/high-power-rocketry-info/
- http://www.ufrocketteam.com/
- http://www.spg-corp.com/space-propulsion-group-resources.html
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