HYBRID ROCKET ENGINE HAVING HIGH REGRESSION RATE

IITM Technology Available for Licensing

Problem Statement

- **Hybrid rocket engines are simple in construction** when compared to liquid rocket engines and it is possible to control the thrust or stop the engine after ignition unlike solid rocket engines.
- However, hybrid rocket engines have **poor regression rate** (rate of reduction of fuel thickness during combustion). **Conventional methods** of increasing the regression rate include improved fuel mixtures and flow conditions such as swirl injection, radial flow and cascaded multi-stage impinging jets. However, these methods may **lead to problems such as unwanted spin** due to swirl injection.
- there is **a need for a hybrid rocket engine** that has **high fuel regression rate** and **overcomes the above challenges.**

Intellectual Property

- IITM IDF Ref.**1129**
- **IN 343577 Patent Granted**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category-Aerospace & Defense Technologies
Industry Classification:

- **NIC (2008)- 30304** Manufacture of spacecraft and launch vehicles, satellites, planetary probes, orbital stations, shuttles, intercontinental ballistic (ICBM) and similar Missiles
- **NAICS (2022)- 336415** Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing

Applications: Manufacture of rocket engines.

Market report:
The global rocket hybrid propulsion market size was valued at $1.03 billion in 2021, and is projected to reach $2.0 billion by 2031, growing at a CAGR of 6.7%

Research Lab

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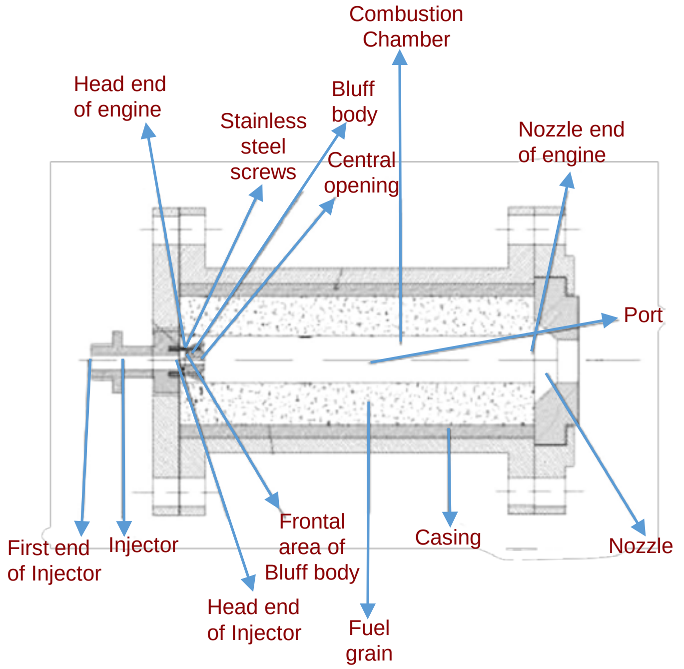

Figure: A schematic diagram of the hybrid rocket engine

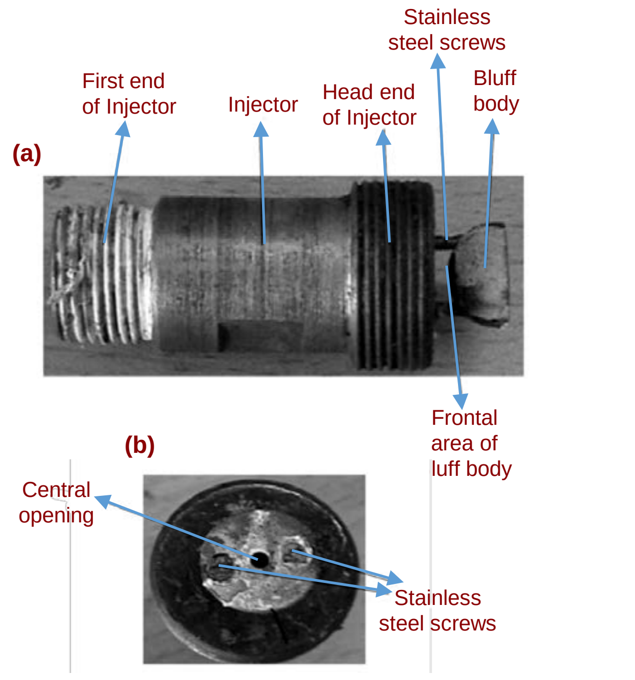

Figure: Depicts **(a)** the front view of the bluff body attached to the injector of the hybrid rocket engine and **(b)** the top view of the bluff body

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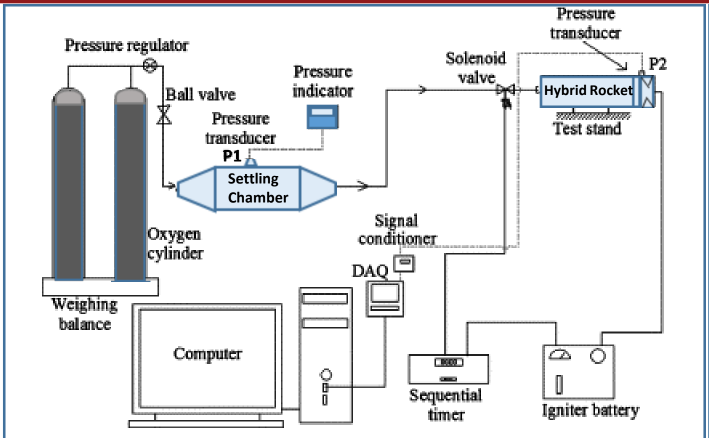

Figure: A graphical representation of the experimental set up for testing the hybrid rocket engine

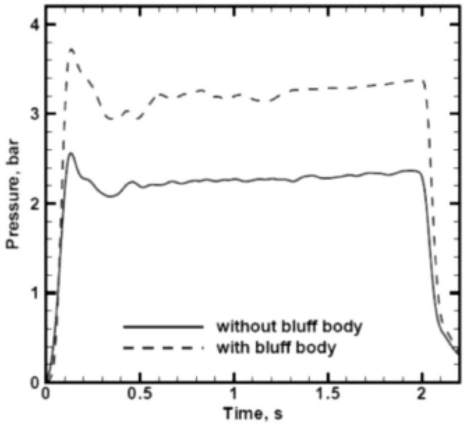

Figure: The combustion chamber pressure with the use of bluff body was higher than the one without it due to two counts, one higher fuel regression rate and two higher characteristic velocities

Technology

- The invention provides a method for maximizing the regression rate in a hybrid rocket engine. The method comprises of attaching a bluff body to the head end of a combustion chamber of the hybrid rocket engine.
- The regression rate increases by around 2 times at higher Oxidizer Mass Flux (G_{ox} =15 g/cm^{2}s) and around 4 times at lower G_{ox} (3 g/cm^{2}s) for the case when a bluff body is used. This increase in regression rate is due to (a) decrease in the recirculation zone size near the head end and (b) redistribution of mass flux close to the wall
- When the bluff body is used, the oxidizer to fuel ratio is nearly constant and the regression rate obtained with different oxidizer flow rates show almost similar regression rates as it eliminates the effect of the recirculation zone at the head end.
- The increase in regression rate observed with bluff body reduces as the L/D (Ratio of total length to initial port diament of fuel) is increased from 9 to 27. However, it is still higher than the case when no bluff body was used.
- The burn rate variation with length of the hybrid rocket engine is less pronounced when a bluff body is used indicating a lower sliver loss
- The bluff body increases the regression rate even at a port diameter (60 mm) which was four times the initial port diameter (15 mm).

Key Features / Value Proposition

- The regression rate comparisons were carried out with an oxidizer mass flow rate of 30 g/s. The oxidizer mass flux for this was around 1.06 g/cm^2 s. The results obtained from the present studies show that with the presence of bluff body regression rate was 1 mm/s, while without the bluff body regression rate was around 0.05 mm/s.
- Compared to solid and liquid fuel rocket engines the hybrid rocket engine enables greater control while having a simpler construction.
- The bluff body in the invented hybrid enginer increases the regression rate. Moreover, the variation in regression rates with mass flowrates of the oxidizer is minimized. Whereas, conventional hybrid engines lacking a bluff body have lower regression rates that show higher variation with changing mass flow rates of oxidizers.

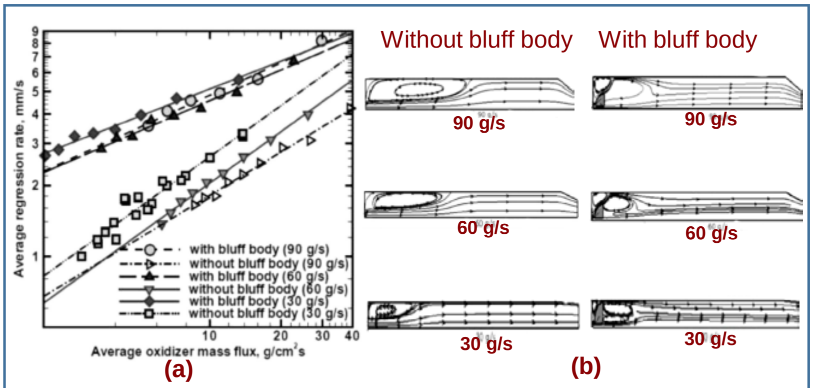

Figure: Depicts **(a)** shows the variation of fuel regression rates at different mass flow rates of the oxidizer for the two cases one without bluff body at the head end and one with the bluff body. The mass flow rate of oxidizer is changed from 30 to 90 g/s. For **(b)** the Cold flow streamline profiles obtained from Fluent™. It is seen that with the bluff body at the head end the size of the recirculation zone is small in all the cases

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