On Demand Thrust Modulation for Solid Rocket Motors

Tech ID: 34354 / UC Case 2025-680-0

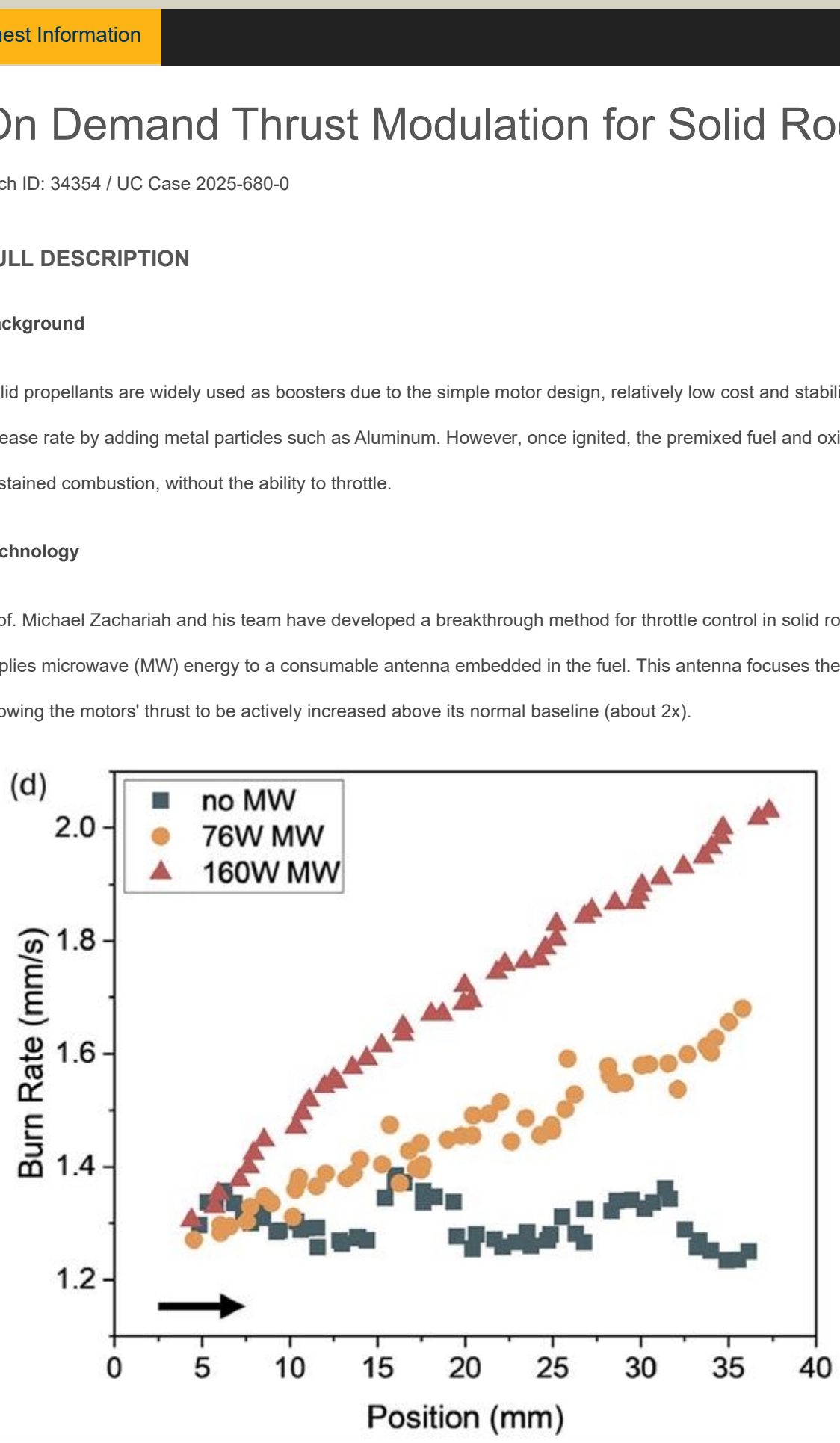
FULL DESCRIPTION

Background

Solid propellants are widely used as boosters due to the simple motor design, relatively low cost and stability. It is common to boost the energy release rate by adding metal particles such as Aluminum. However, once ignited, the premixed fuel and oxidizer are designed to maintain self-sustained combustion, without the ability to throttle.

Technology

Prof. Michael Zachariah and his team have developed a breakthrough method for throttle control in solid rocket motors. A control system applies microwave (MW) energy to a consumable antenna embedded in the fuel. This antenna focuses the energy at the burning surface, allowing the motors' thrust to be actively increased above its normal baseline (about 2x).



Comparison of local burn rate of 40mm propellants with MW antenna and under different MW stimulation power levels. The propagation direction was from left to right, as indicated by the arrow.

ADVANTAGES

- Provides on-demand control to **increase** thrust above a solid motor's fixed baseline rate, allowing for real-time mission adjustments
- Adds a new, critical capability without incurring the extreme cost, weight and complexity of a liquid-fuel engine.
- The burn rate increase is linear with the amount of microwave power applied, allowing for fine-tuned and predictable thrust modulation.
- The control method focuses energy on the burning surface without causing instability, cracks, or premature decomposition in the underlying propellant.
- The method is designed to work with common propellants and can be integrated into existing motor designs.

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OTHER INFORMATION

KEYWORDS

solid propellant, thrust control, rocket motor throttling, burn rate modulation, propulsion technology, aerospace, defense technology, microwave-assisted combustion, embedded antenna, mission flexibility

CATEGORIZED AS

- **Materials & Chemicals**
  - Composites
  - Nanomaterials
- **Security and Defense**
  - Other
- **Transportation**
  - Aerospace
  - Alternative Propulsion

RELATED CASES

2025-680-0

SUGGESTED USES

- **Aerospace & Defense**: Controllable boosters for launch vehicles, enabling optimized gravity turns and orbital insertions.
- **Tactical Missiles**: Variable "boost" control for improved range, trajectory shaping, and end-game maneuverability.
- **Space Systems**: Controllable solid-propellant thrusters for satellite orbit adjustments and space exploration missions.

STATE OF DEVELOPMENT

- Proof-of-concept demonstrated. Technology and burn rate modulation has been tested and validated with lab prototype

INVENTOR INFORMATION

- Please see all inventions by Prof. Zachariah and his team at UCR
- Please visit Prof. Zachariah's research group website to learn more about their research
- Read news coverage of Prof. Zachariah's research at UCR

RELATED MATERIALS

- Consumable embedded microwave Antenna in AP/HTPB propellant to focus energy at the reaction front

PATENT STATUS

Patent Pending

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