National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Propulsion

Fast-Acting, Deep-Throttling Hybrid Motor

Improved Deep-Throttle Response Times for a Wider Capability Hybrid Motor System

NASA Marshall Space Flight Center and collaborators at Utah State University have developed a prototype for a highly efficient hybrid motor designed for spacecraft. This innovative motor addresses the need for both substantial propulsion during orbital maneuvers and precise control for attitude adjustments and stability.

Hybrid motors offer a variety of advantages over traditional liquid and solid propulsion systems. Hybrid motor systems are significantly simpler than a liquid engine system, and offer safety gains and possible throttling capabilities compared to a solid rocket motor. However, the practical implementation of rapid throttling has presented significant challenges in the industry. The NASA motor tackles this hurdle by leveraging a digital valve technology, effectively reducing full-scale throttle time to one second or less and enabling the potential for rapid restart and short pulses of thrust.

This hybrid motor technology holds promise for the future of space exploration and offers potential solutions for improved motors on low earth orbit spacecraft (commercial or government) as well as sounding rockets, missiles, and other systems.

BENEFITS

- Improved throttling speed: the hybrid motor design with a digital valve cut the throttle time in half (2 seconds to 1 second) and may be capable of further reduction to 0.5 seconds.
- Deep throttling potential: the motor and valve design may be capable of achieving >40:1 thrust ratios for relatively small motors (<1000 N).
- Cheaper, simpler propulsion systems: by combining main propulsion and reaction control systems into a single unit, the overall propulsion system may be cheaper and simpler.
- Increased safety: the technology here is an alternative to using hypergolic propellants like hydrazine, which are dangerous and expensive to store and handle.
- Enabling unique flight profiles: the advanced capabilities of the hybrid motor will allow flight profiles previously requiring significantly more expensive propulsion systems, especially for defense-related systems like missiles.

THE TECHNOLOGY

Hybrid chemical motors offer an alternative to traditional liquid or solid motors for spacecraft, missiles, rockets, or other vehicles. The key advantage of a hybrid motor is the capability to throttle the motor via active control, which cannot be done in solid propellant motors. However, rapid throttling presents significant challenges to implement in practice.

Here, NASA has combined a deep-throttling hybrid motor previously developed by Utah State University with a fast-acting digital valve design to produce a fast-acting, deep-throttling hybrid. Testing performed to-date using a prototype of the hybrid motor and digital valve design has shown the new hybrid motor to be capable of full-scale throttling twice as fast (1 second throttling compared to 2 seconds) as previous control valve designs. With optimization, there is potential full-range throttling may be further reduced to 0.5 second, a 4x improvement over previous control valve designs for hybrid motors. Additionally, smaller mid-range thrust changes have currently been measured in the <0.5 second range.

With the throttling capability enabled by the implemented digital valves, it also becomes feasible to achieve thrust ratios of >40:1 for relatively small motors (<1000 N), opening up the opportunity to replace both the main propulsion system (MPS) and reaction control system (RCS) with a single, more efficient motor capable of meeting the needs of both on a spacecraft.

The hybrid motor is at technology readiness level (TRL) 4 (component and/or breadboard validation in laboratory environment) and is available for patent licensing.

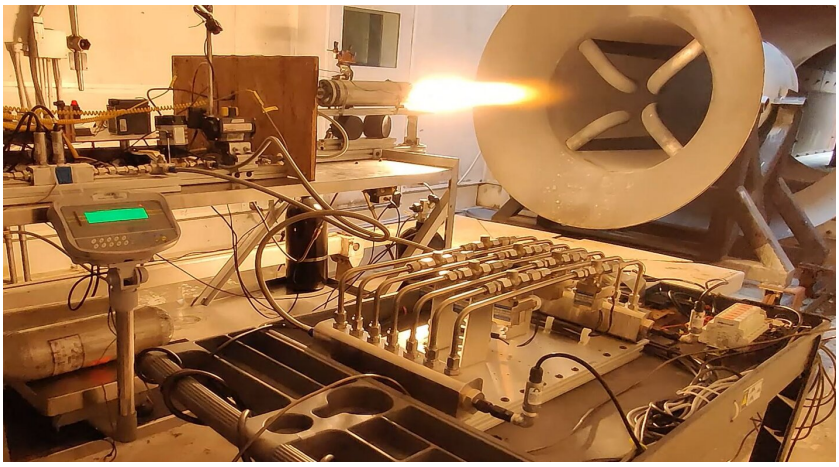

Image of the hot-fire test of the fast-acting, deep-throttling hybrid motor at Utah State University's Propulsion Research Laboratory. The digital valve is shown in the foreground, and the hybrid motor is in the background of the frame.

APPLICATIONS

The technology has several potential applications:

- Aerospace: replacing conventional propulsion systems in low earth orbit (LEO) spacecraft.
- Defense: improving flight capabilities of defense systems (e.g., missiles)
- Aerospace: if scaled up to higher thrusts, can be applied to sounding rockets and planetary or lunar landers

PUBLICATIONS

Patent Pending

Whitmore, S. A.; Smith, A. N.; 2022 JANNAF In-Space Chemical Propulsion Technical Interchange Meeting. Huntsville, AL. Digital Throttling of a Hybrid Rocket Motor.

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More Information

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