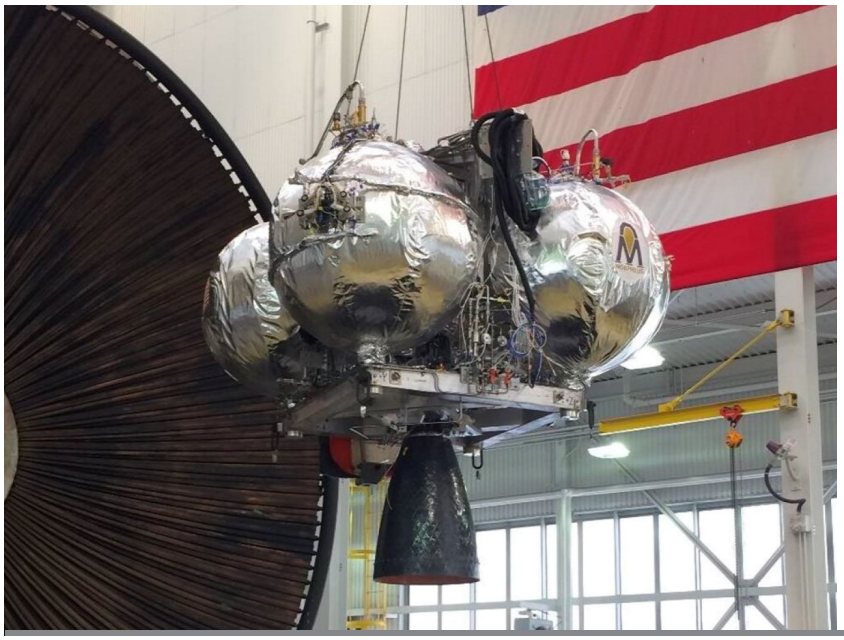


National Aeronautics and Space Administration

TECHNOLOGY SOLUTION

Electrical and Electronics

Coil-On-Plug Igniter for Reliable Engine Starts

Compact igniter reduces thermal-vacuum corona discharge issues

Innovators at NASA Johnson Space Center have developed a coil-on-plug ignition system for integrated liquid oxygen (LOX)/liquid methane (LCH4) thermal-vacuum environment propulsion systems operating in a thermal vacuum environment. The innovation will help quell corona discharge issues and reduce overall mass. Corona discharge represents a local region surrounding a high-voltage conductor where air has undergone an electrical breakdown and become conductive due to ionization, allowing a charge to leak off the conductor and cause a possible malfunction.

NASA worked with commercial vendors to modify off-the-shelf automotive coil-on-plug spark plug systems for use with LOX/LCH4 igniters. The coil-on-plug configuration eliminates the bulky standalone coil-pack and conventional high-voltage spark plug cable by combining the coil and the spark plug into a single component. The test campaign successfully proved that coil-on-plug technology can enable integrated LOX/methane propulsion systems in future spacecraft.

BENEFITS

- Compact: Design provides sparking energy at the point-of-use (directly to combustion chamber)
- Durable: Eliminates need for fragile-shielded and sealed high voltage conductors
- Low Mass: Reduces weighty exciter electronics and conductors
- Reliable: Low supply voltage operation reduces potential for corona discharge

APPLICATIONS

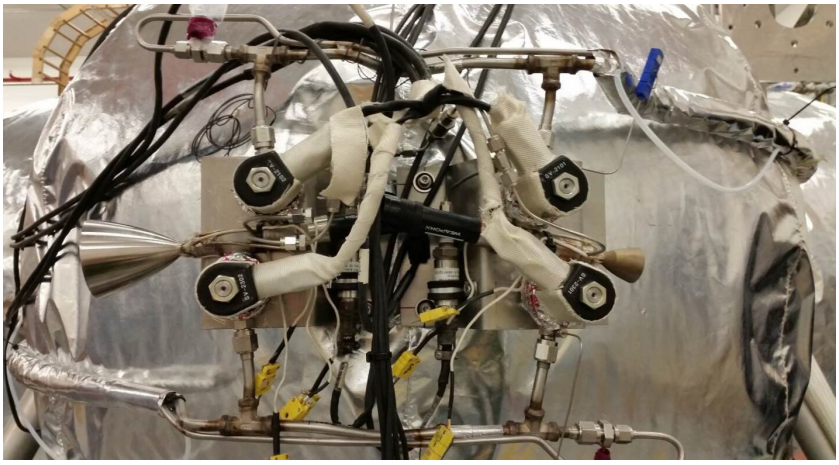
The technology has several potential applications:

- Thrusters: integrated cryogenic thruster development, testing, and spaceflight
- Burners: industrial flame-control systems and emissions-control flaring systems

THE TECHNOLOGY

Spark-ignition devices have proven to be a high-reliability option for LOX/LCH4 ignition during development of the Integrated Cryogenic Propulsion Test Article (ICPTA) main and reaction control engines (RCEs); however, issues including spark plug durability (ceramic cracking) and corona discharge during simulated altitude testing have been observed, contributing to degraded spark output and no-light engine-start conditions. Innovators discovered that ignition system reliability could be improved and weight reduced by eliminating the traditional coil and spark plug wire. To achieve this result, engineers made the innovation by modifying an automotive coil-on-plug igniter to provide new high sparking energies at the point of combustion using low supply voltages. The coil was modified by vacuum-potting it into a threaded interface that mounts into existing spark plug ports on the ICPTA main engine and the RCEs. Engineers fabricated custom electrode tips that were thread-mounted into the potted coil body. Epoxy insulation was chosen with high dielectric strength to maintain insulation between the electrode and threaded adapter. Vacuum potting successfully prevented pressure or vacuum leakage into the coil body and maintained spark energy and location at the electrode tip. Successful hot-fire ignition was observed at sea-level, altitude, and thermal-vacuum for both ICPTA RCE and main engine igniters down to 10^-3 torr, which approaches the vacuum of cislunar space.

This technology is at technology readiness level (TRL) 7 (system prototype demonstration in an operational environment), and the related patent is now available to license. Please note that NASA does not manufacture products itself for commercial sale.



ICPTA reaction control system pod with one 28 lbf-vac engine (left) and one 7 lbf-vac engine (right) installed with coil-on-plug spark igniter.

Top: Conventional spark plug with external coil and high voltage-cable. Bottom: Coil-on-plug spark plug system with high voltage cable eliminated.

PUBLICATIONS

Patent Pending

Coil-On-Plug Ignition for LOX/Methane Liquid Rocket Engines in Thermal Vacuum Environments. 2017. AIAA. Melcher et al. (Link: https://ntrs.nasa.gov/citations/20170004966)

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More Information

National Aeronautics and Space Administration

Agency Licensing Concierge

Johnson Space Center

2101 NASA Parkway
Houston, TX 77058
202-358-7432
Agency-Patent-Licensing@mail.nasa.gov

www.nasa.gov

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