Advanced Chemical Propulsion

In-Space Propulsion Technology Project

Chemical propulsion has provided the basis for rocket system transportation since the successful launch of first liquid fuel rocket in 1926 by Dr. Robert Goddard. As NASA prepares for future space exploration, the Agency continues to improve and develop new chemical propulsion systems. In doing so, there is both the need and opportunity to reduce the mass of launch vehicle systems, cost of space exploration, and to provide greater capabilities for science investigations. Our current efforts in advanced chemical propulsion aim to provide increased payload capacity and decreased trip time for scientific missions to the outer planets, while reducing propulsion system cost.

Seeking to fulfill these goals, the In-Space Propulsion Technology Office, located at NASA Glenn Research Center, is currently investigating innovative rocket combustion chamber design and manufacturing methods that offer higher engine performance that is higher specific impulse (Isp). The project is also developing optimized and lightweight advanced propulsion system components.

Advanced Materials Bipropellant Rocket (AMBR) Engine

For bi-propellant space chemical engines, the maximum theoretical performance of the propellants nitrogen tetroxide and hydrazine (NTO and N_4H_4 respectively) have never been reached partially due to the temperature limitation of the rocket chamber material and engine design. Consequently, if improvements are made so that the engine is allowed to operate at a higher temperature and pressure, then better performance is possible. .

To achieve the higher performance goals, iridium coated rhenium (Ir/Re) engine chambers using advanced manufacturing techniques to allow operation at temperatures closer to the materials' capability of 4,000 degree F. This task addresses optimization of the engine design, and materials and manufacturing processes – tasks that are the content of this project.

Specifically, the present effort investigates better coating methods to reduce process cost while strengthening the chamber. This will allow a high

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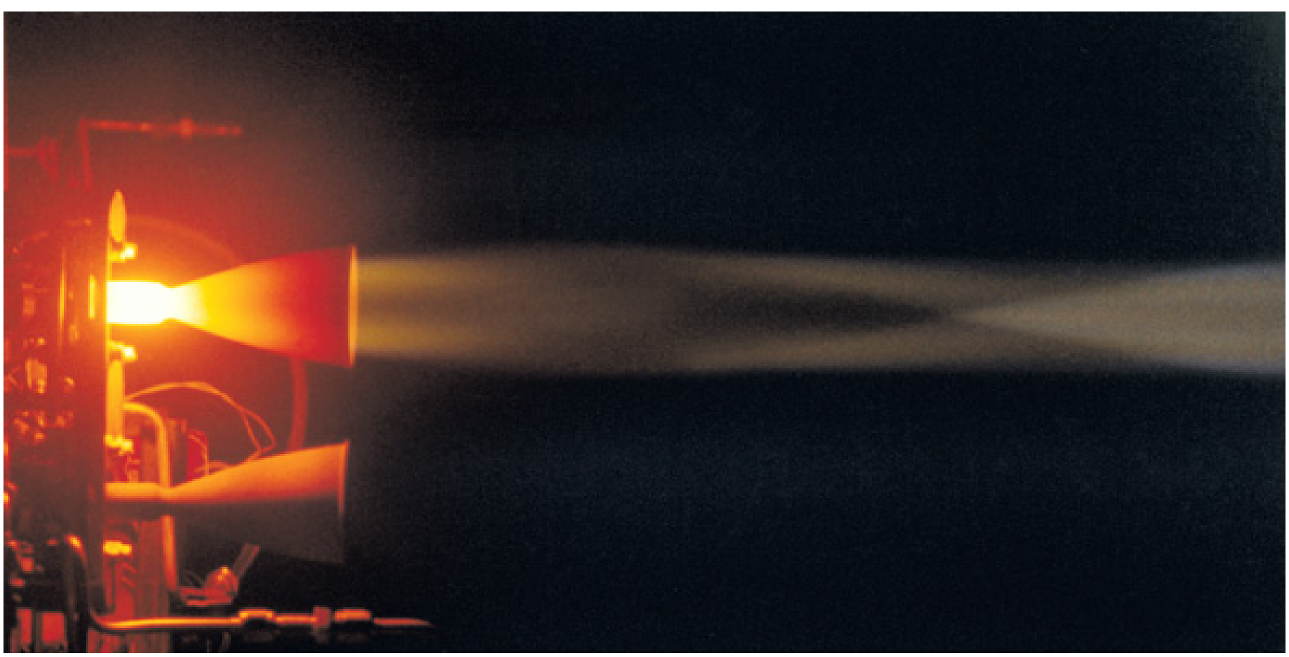

Aerojet Bi-propellant Hot-fire Test

temperature operation of the Ir/Re rocket engine. Equally if not more importantly, it also ensures that the engine design is optimized in order to take advantage of the capability of the chamber materials.

It is expected that by 2009, the AMBR engine will be ready to enable increased payload capabilities in many space missions including those of Discovery, New Frontier, and Flagship classes.

Pressurization and Mixture Ratio Control

The motivation for this work was to reduce the amount of propellant reserve for in-flight consumption variance. If the amount of propellant reserve were reduced by a half, the mass savings could be significant – as much as a 10% reduction in propulsion hardware mass, or a 15 to 50% gain in scientific payload depending on the mission.

Initial project activities included assessing the active ability for propellant mixture ratio control to confirm that this technology can be developed for a reasonable investment. To date, several sub-component technologies have been reviewed, and a couple have graduated to the next level of development. These include the advanced flow meters and new tank liquid mass gauging techniques. The former can potentially minimize the error in propellant flow measurement down to 0.15%, and the latter can minimize the volume measurement down to less than 0.5%, both are significant improvements over state-of-the-art.

Propellant pressurization feed system control algorithms have been studied using advanced statistical methods to assess performance and impact on reduction of in-flight propellant reserves.

Reliable Lightweight Tanks Components

The developments in this area were to advance designs, material, and manufacturing technologies for lighter-weight in-space propulsion system tanks. A composite over-wrapped tank provides added strength to the inner, thin walled metallic tank that stores spacecraft propellant and pressurant for a propulsion system.

Typically, propellant tanks are the largest component of in-space chemical propulsion systems and add significant mass to the spacecraft. Lightweight tanks could reduce tank mass by 50% while maintaining the same strength and corrosion resistance.

Tasks under light-weight tank technology included improving welding of the liner and components, bonding between the composite overwrap and the liner, and inspection criteria and techniques.

More about the Advanced Chemical Propulsion Program

Development of advanced chemical propulsion for in-space applications focuses on near-term products that are built on the proven, state-of-the-art chemical propulsion systems. The ISPT Project aims to optimize current technology to improve propulsion systems performance, yielding more capable, cost-efficient exploration of the space frontier.

Developments in the technology area are being funded by the In-Space Propulsion Technology Program, which is managed by the Glenn Research Center for NASA's Science Mission Directorate. The program's objective is to develop in-space propulsion technologies that can enable or benefit near and mid-term NASA space science missions by significantly reducing cost, mass and travel times.

For more information about NASA's In-Space Propulsion program and advanced chemical propulsion, visit:

http://www.nasa.gov
http://www.grc.nasa.gov/WWW/InSpace/

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